H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9744/01

Paper 1 Multiple Choice

24 September 2019

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, CT and NRIC on the Answer Sheet in the spaces provided unless this has been done for you.
DO NOT WRITE IN ANY BARCODES.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **20** printed pages.

[Turn over

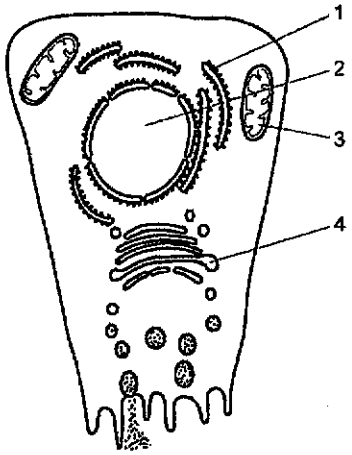
1 The table shows some of the structural features present or absent in four different cell types.

Which identifies the cell type for each column of features?

key
✓= feature present
× = feature absent

cell wall	✓	×	✓	✓
centrioles	×	✓	×	×
chloroplast	✓	×	×	×
mitochondria	✓	✓	×	✓
golgi apparatus	✓	✓	×	✓
A	palisade mesophyll cell	bacterial cell	blood stem cell	yeast cell
B	palisade mesophyll cell	blood stem cell	bacterial cell	yeast cell
C	palisade mesophyll cell	yeast cell	blood stem cell	bacterial cell
D	palisade mesophyll cell	yeast cell	bacterial cell	blood stem cell

2 Radioactively-labelled nucleotides are introduced into a cell.



In which cell structures will the radioactivity first become concentrated?

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

3 The main steps in fractionation, a process used to separate cell components, are shown below.

- Cells are broken open in buffer solution.
- The mixture is centrifuged at low speed.
- The largest and densest organelles sediment. ⟶ sediment 1
- The supernatant is removed and centrifuged at a higher speed .
- The next smaller and less dense organelles sediment. ⟶ sediment 2
- The supernatant is removed and centrifuged at higher speed.
- The next smaller and less dense organelles sediment. ⟶ sediment 3
- The supernatant is removed and centrifuged at a higher speed .
- The smallest and least dense organelles sediment. ⟶ sediment 4

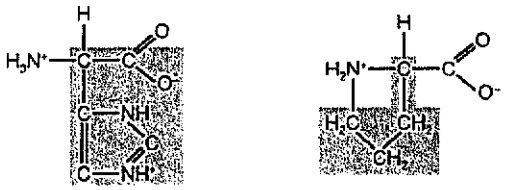
The sediments obtained from fractionation of a plant cell were tested for biochemical activity. DCPIP and buffer solution were added and the mixtures left in the light for fifteen minutes.

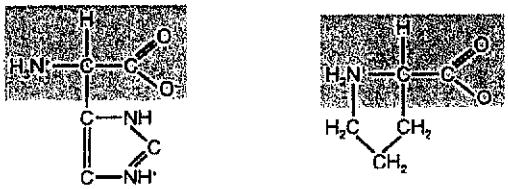
In which sediments would the blue oxidised DCPIP be reduced?

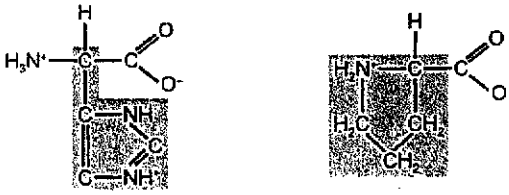
A 1 and 2 **B** 2 and 3 **C** 2 and 4 **D** 3 and 4

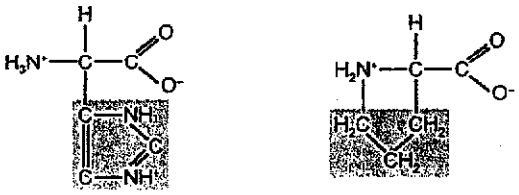
4 Students were asked to highlight only the R groups of two ring-shaped amino acids.

Which pairs of diagram is correct for both amino acids?

A 

B 

C 

D 

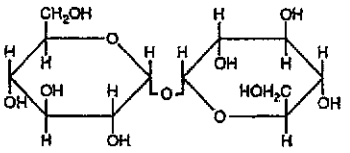
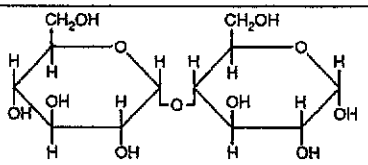
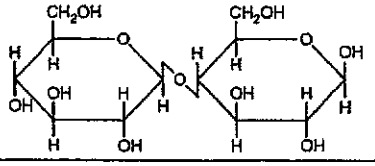
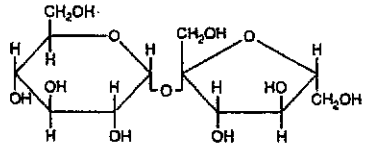
5 Disaccharides are formed following synthesis from monosaccharides or as a result of polysaccharide hydrolysis.

Cellobiose, maltose, sucrose and trehalose are four different disaccharides found in nature.

Some features of these disaccharides are listed.

- The disaccharide cellobiose is formed from the hydrolysis of the polysaccharide cellulose.
- Sucrose is composed of glucose and fructose.
- Trehalose is a non-reducing disaccharide that is synthesised from two α-glucose molecules.
- The disaccharide maltose is formed from the hydrolysis of amylose, a component of starch.

Which column correctly identifies each disaccharide?

	A	B	C	D
	cellobiose	maltose	sucrose	trehalose
	maltose	cellobiose	trehalose	maltose
	sucrose	trehalose	cellobiose	cellobiose
	trehalose	sucrose	maltose	sucrose

6 The enzyme rennin is found in gastric juice of young mammals. It causes the clotting of milk protein. The activity of rennin was investigated by recording the time taken for rennin to clot milk in different conditions. The table shows the different conditions used and the results of the investigation.

tube	solutions added to 10 cm^3 of milk at 35 °C						time for milk to clot/min
	2% rennin	water	calcium nitrate	calcium citrate	lead nitrate	hydrochloric acid	
1	5 cm^3		2 cm^3			2 cm^3	1
2	5 cm^3				2 cm^3	2 cm^3	No clot
3		5 cm^3	2 cm^3			2 cm^3	No clot
4	5 cm^3	2 cm^3		2 cm^3			25
5	5 cm^3	2 cm^3				2 cm^3	10
6	5 cm^3			2 cm^3		2 cm^3	2

What is a correct conclusion?

A Calcium ions increase the activity of rennin.

B Citrate ions are necessary for the activity of rennin.

C Hydrochloric acid is necessary for the activity of rennin.

D Nitrate ions inhibit the activity of rennin.

7 Blood transfusion laboratories around the world are hoping to produce large numbers of red blood cells (rbcs) from 'spare' human embryos produced during in vitro fertilisation procedures.

Embryonic stem cells are removed from an embryo and cultured in a growth medium that stimulates their differentiation into rbcs.

Which statement correctly describes this differentiation?

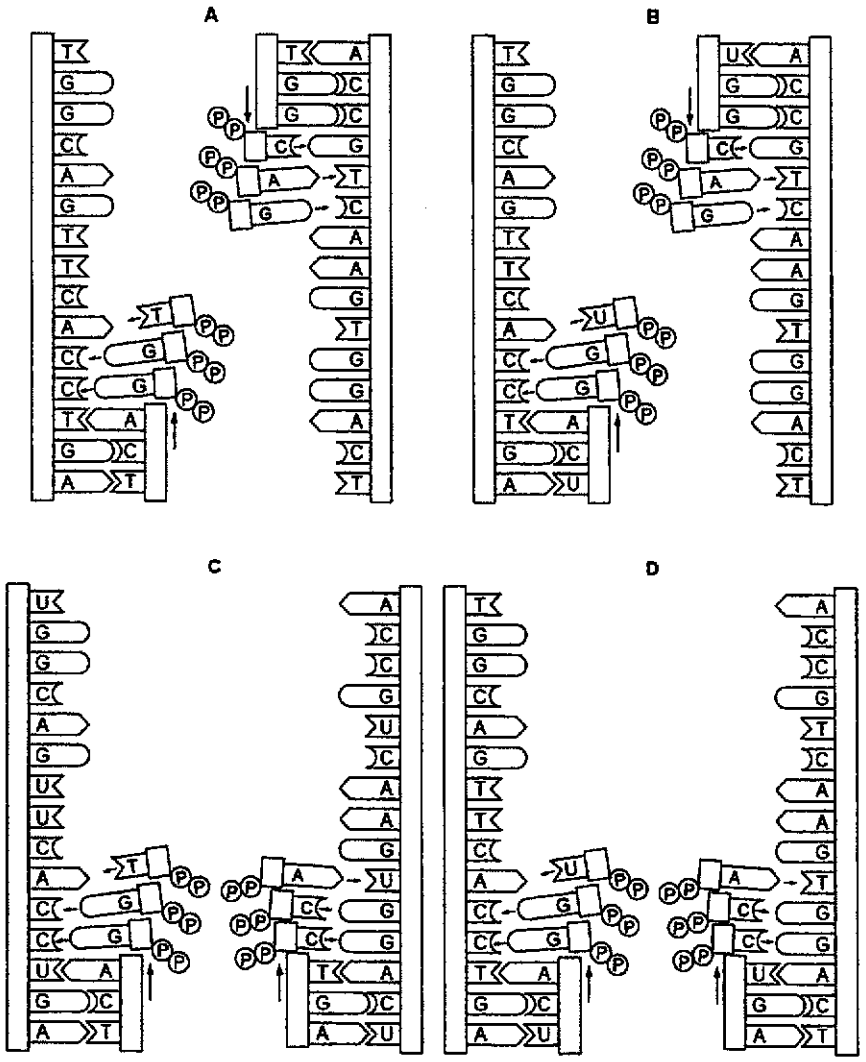
A Multipotent embryonic stem cells differentiate into pluripotent blood stem cells and then into rbcs.

B Pluripotent embryonic stem cells differentiate into multipotent blood stem cells and then into rbcs.

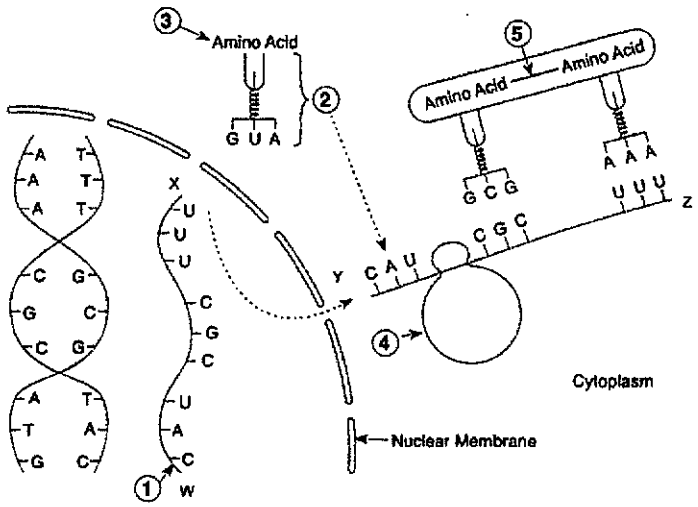
C Totipotent embryonic stem cells differentiate into multipotent blood stem cells and then into rbcs.

D Totipotent embryonic stem cells differentiate into pluripotent blood stem cells and then into rbcs.

8 Which diagram shows the semi-conservative replication of a section of a molecule of DNA?



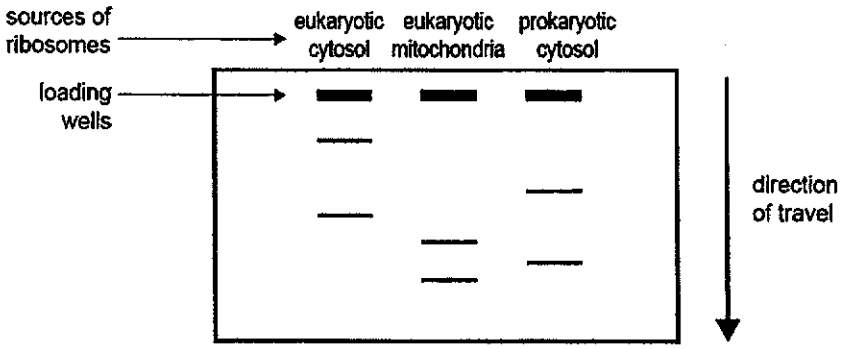
9 The diagram below represents some biochemical reactions involved in protein synthesis.



Which is correct?

	Entire molecule coded directly from DNA is represented by	5' end of molecule	Enzyme involved in catalysing bond 5
A	1 and 2	Z	peptidyl transferase
B	1 and 2	Y	aminoacyl tRNA synthethase
C	1, 2 and 3	X	aminoacyl tRNA synthethase
D	1, 2 and 4	W	peptidyl transferase

10 A ribosome contains two distinct sub-units: a large sub-unit and a small sub-unit. Ribosomes from prokaryotic and eukaryotic cells were isolated and subjected to gel electrophoresis. The results are shown below.



Which one of the following can be correctly concluded from the gel electrophoresis results?

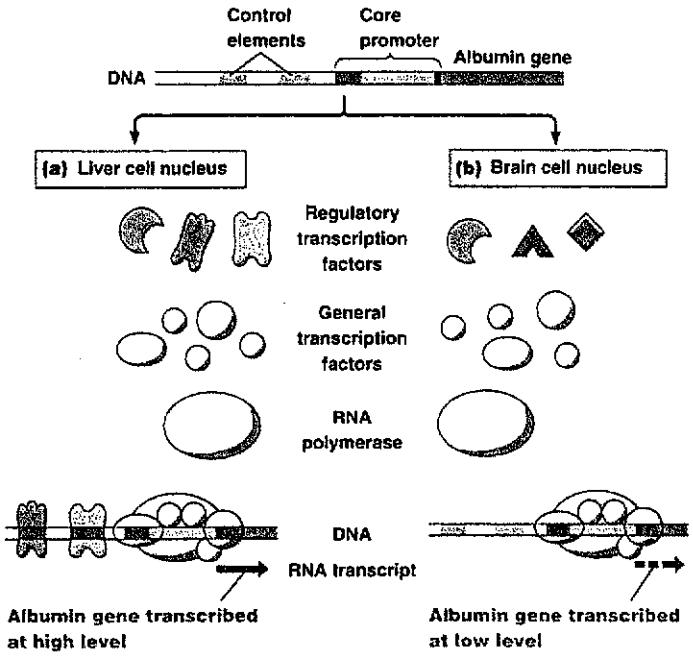
A Eukaryote cytosolic and mitochondrial ribosomes translate the same types of protein.

B Eukaryote mitochondria contain the ribosomal sub-units of the smallest size.

C Prokaryote ribosomal sub-units have opposing charges to each other.

D Eukaryote cytosolic ribosomal sub-units travel at the greatest speeds.

11 Gene expression of albumin gene is regulated by two control elements and its promoter.



Which of the following is a result of differential albumin gene expression in liver cells and brain cells?

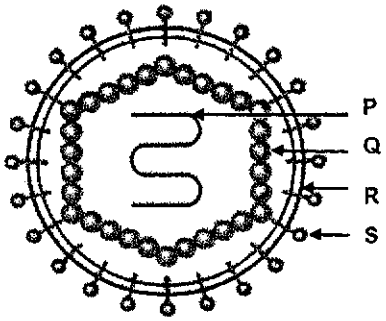
A Liver and brain cells are differentiated from different pluripotent stem cells, hence they contain different control elements which result in differential gene expression.

B Brain cells contain different RNA polymerases and general transcription factors resulting in low transcription of the albumin gene.

C Brain cells do not contain the regulatory transcription factors that are required to bind to the control elements of the albumin gene to promote the assembly of the transcription complex.

D Liver and brain cells contain the same regulatory control elements, RNA polymerase and transcription factors but a mutation has occurred in the regulatory control elements of the brain cells hence making them dysfunctional.

12 The diagram shows the structure of a virus.



Which of the following statements are true?

1 **P** determines the structure of **Q** and **S**.
2 **Q** assists viral entry into the host cell.
3 **R** and **S** are required for the entry of the virus into the host cell.
4 **Q** and **R** are made of the same components.

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

13 Which of the following statement(s) concerning *trp* operon is/are true?

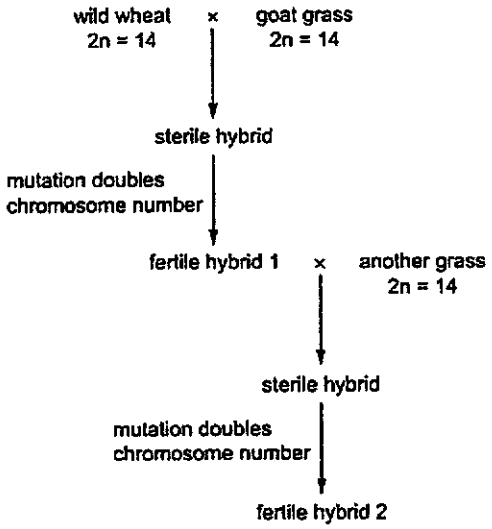
1 A deletion mutation of the operator will lead to the constitutive production of tryptophan.
2 There is one start and one stop codon in the mRNA of trp operon.
3 The repressor is inactive in the presence of excess tryptophan.
4 The mRNA codes for 3 polypeptides involved in the synthesis of tryptophan.

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

14 Which of the following pairs of statements is **true** of transduction and conjugation?

	Transduction	Conjugation
A	Bacterial DNA is transferred from donor cell to recipient cell	Bacterial DNA is transferred from donor cell to recipient cell
B	Only host DNA adjacent to prophage is transferred from donor cell to recipient cell in specialised transduction	F plasmid is exchanged between donor cell and recipient cell
C	Lambda lysogenic phage is involved in generalised transduction	T4 lytic phage is involved
D	Viral DNA is replicated via rolling-circle mechanism in the donor cell	DNA on F plasmid is replicated via rolling-circle mechanism in the donor cell

15 The diagram shows crosses between wild wheat and two types of grass.



What is the chromosome number of the fertile hybrid 2?

A 28 B 42 C 56 D 140

16 Gene mutations in either the BRCA1 or the BRCA2 genes are responsible for the majority of hereditary breast cancer in humans.

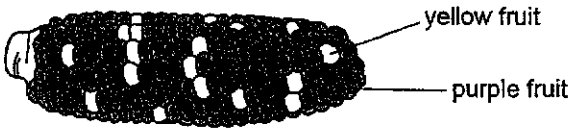
The proteins produced by the two genes migrate to the nucleus where they interact with other proteins, such as those produced by the tumour suppressor gene, *p53*, and the DNA repair gene, *RAD51*.

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

	gene		
	BRCA1 or BRCA2	*p53*	*RAD51*
A	✓	✓	✓
B	✓	✓	×
C	✓	×	✓
D	×	×	×

key
✓ = gene produces normal protein
× = gene produces abnormal or no protein

17 The diagram shows a maize (corn) cob with purple and yellow fruits. Purple (P) is dominant to yellow (p).



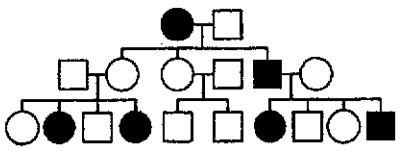
What are the genotypes of the parent maize plants?

A PP × Pp B PP × pp C Pp × Pp D pp × Pp

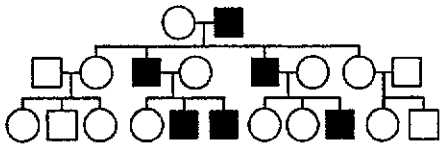
18 Kearns-Sayre syndrome is a rare genetic trait caused by a deletion of up to 10 000 nucleotides from the mitochondrial DNA (mtDNA). Most individuals with this syndrome have weak eye muscles, drooping eyelids, vision loss and, often, short stature.

The pedigree that shows a family affected by a mitochondrial trait such as Kearns-Sayre syndrome is

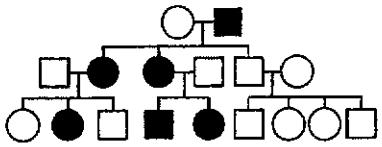
A



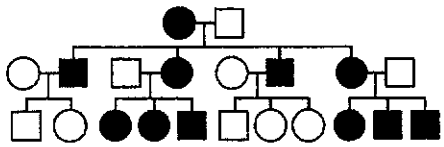
B



C



D



19 Two gene loci that control red seed colour in wheat have the following alleles.

Gene locus 1 :	R_1^+ : red colour R_1^- : no colour	Gene locus 2 :	R_2^+ : red colour R_2^- : no colour

The number of R_1^+ or R_2^+ alleles present in a wheat seed determines the darkness of red in the seed.

It would be reasonable to expect that with regard to wheat

A a plant with the genotype $R_1^- R_1^- R_2^- R_2^-$ could be a parent of a seed with the darkest red colour.

B seeds with genotypes $R_1^+ R_1^+ R_2^- R_2^-$ and $R_1^- R_1^- R_2^+ R_2^+$ would have the same red colour.

C parents $R_1^+ R_1^+ R_2^- R_2^-$ × $R_1^- R_1^- R_2^+ R_2^+$ could produce seeds with the darkest red colour.

D seeds with the genotype $R_1^+ R_1^+ R_2^+ R_2^-$ would have a lighter red colour than seeds $R_1^- R_1^- R_2^+ R_2^+$

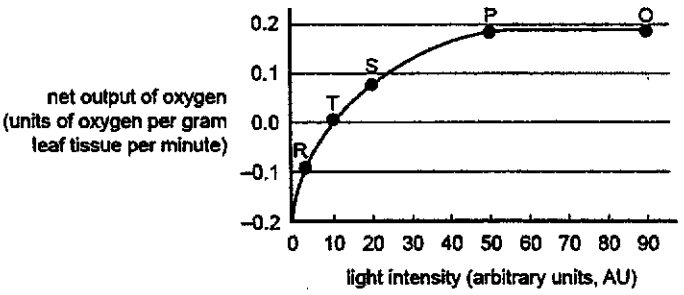
20 Which stages of aerobic respiration in eukaryotes have the correct products?

	ATP	CO_2	FAD	NAD	reduced NAD
1 glycolysis	✓	×	×	×	✓
2 oxidative phosphorylation	✓	×	✓	✓	×
3 Krebs cycle	✓	✓	✓	×	✓
4 link reaction	✓	✓	×	×	✓

key
✓ = product
× = not a product

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

21 The graph below shows the net output of oxygen in spinach leaves as light intensity is increased.
Temperature is kept constant during the experiment.



Which one of the following conclusions can be made based on the graph?

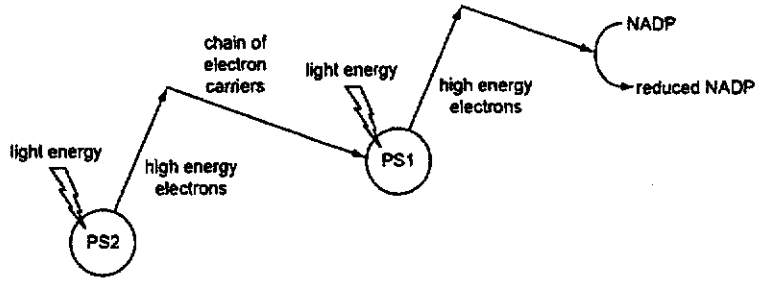
A At point **T** photosynthesis is no longer occurring.

B The optimal level of light intensity for photosynthesis is 40 AU.

C At point **S** the amount of oxygen output is a third of that at point **P**.

D Below 10 AU of light intensity the aerobic respiration rate is greater than the photosynthesis rate.

22 The diagram shows some of the processes in the light-dependent stage of photosynthesis.



For the light-dependent stage to continue, photosystem two (PS2) must gain electrons.

Where do these electrons come from?

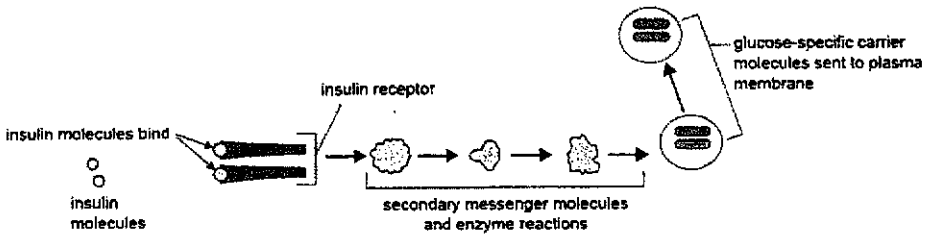
A electron carriers

B reduced NADP

C photolysis

D the formation of ATP

23 A scientist studied the insulin signalling pathways of two female patients, Eleni and Shani.



Eleni's pathway is the same as that shown in the diagram above.

The scientist discovered that the gene that encodes the insulin receptor in Shani has a mutation. Insulin molecules cannot bind to Shani's insulin receptors.

From this information, it would be correct to conclude that

A insulin acts as a hydrophilic signalling molecule in Eleni and Shani.

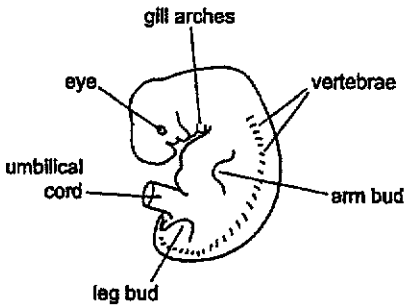
B there would be more glucose-specific carrier molecules in Shani's plasma membranes than in Eleni's.

C the binding of insulin molecules to the receptor initiates transduction and the uptake of glucose into Eleni's cells.

D the presence of insulin in Shani would cause an increase in the concentration of the secondary messenger molecules.

24 All vertebrate embryos share many homolgies.

The diagram shows a five-week-old human embryo.



If vertebrates did not have a common ancestry, which feature of the human embryo shown would be most unexpected?

A arm and leg buds

B gill arches

C umbilical cord

D vertebrae

25 The colours of butterfly wings are produced by microscopic overlapping scales, which also serve to repel water. The wings of some species of butterfly found in rainforests have large transparent areas. These seem to confuse predators by breaking up the shape of the butterfly. The transparent areas have very few scales, so the butterflies are vulnerable to wing damage in the rain.

How could these selection pressures affect the size of the transparent areas of the wings of populations of these species of butterfly?

1 smaller transparent areas on the wings due to natural selection in which the selection pressure is predation

2 larger transparent areas on the wings due to natural selection in which the selection pressure is the quantity of rainfall

3 no change in the size of the transparent areas on the wings due to stabilizing selection, in which the selection pressures are predation and quantity of rainfall

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

26 A comparison was made between human, rabbit, mouse and chimpanzee of the

- DNA coding sequence of the β globin gene
- DNA sequence in the introns of the β globin gene
- amino acid sequence of the β globin polypeptide.

The data is shown below.

	sequence similarity (%)		
Organisms being compared	**coding DNA**	**introns**	**amino acid sequence**
Human β globin/chimpanzee β globin	100	98.4	100
Human β globin/rabbit β globin	89.3	67	90.4
Human β globin/mouse β globin	82.1	61	80.1

It is possible to conclude from this data that

A a human is more closely related to a mouse than to a rabbit.

B the variation between chimpanzees and humans occurs in a region of the β globin gene which would code for amino acids.

C the variation in the intron sequence between human and mouse would account for some of the differences in the amino acid sequence.

D the comparison between chimpanzee and human indicates that the differences in their DNA did not always make a difference to the amino acid produced.

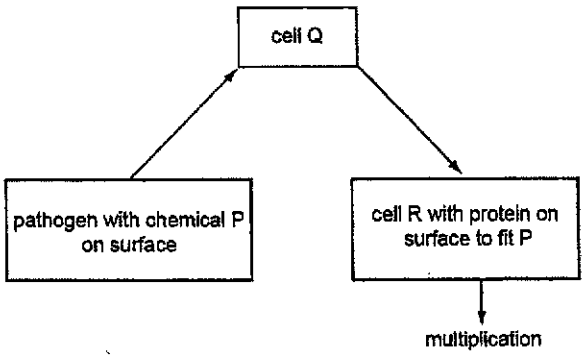
27 Whales and snakes do not have any hind limbs, but their skeletons still have the small bones that in other vertebrates are part of the pelvic girdle. The pelvic girdle is important in the functioning of hind limbs. Whales and snakes do not move in the same way as each other.

What does this suggest about the evolution of whales and snakes?

1 Their movement involves the same adaptations of the skeleton.
2 As their ancestors evolved and adapted to different habitats, the pelvic girdle lost its function.
3 They are descendants of different groups of animals that used their hind limbs for movement.
4 They share a common ancestor that used hind limbs for movement.

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

28 The diagram shows part of the immune response.



What are P, Q and R?

	P	Q	R
A	antibody	B-lymphocyte	T helper cell
B	antibody	T helper cell	B-lymphocyte
C	antigen	B-lymphocyte	T helper cell
D	antigen	T helper cell	B-lymphocyte

29 Which of the following describes a positive feedback concerning climate change?

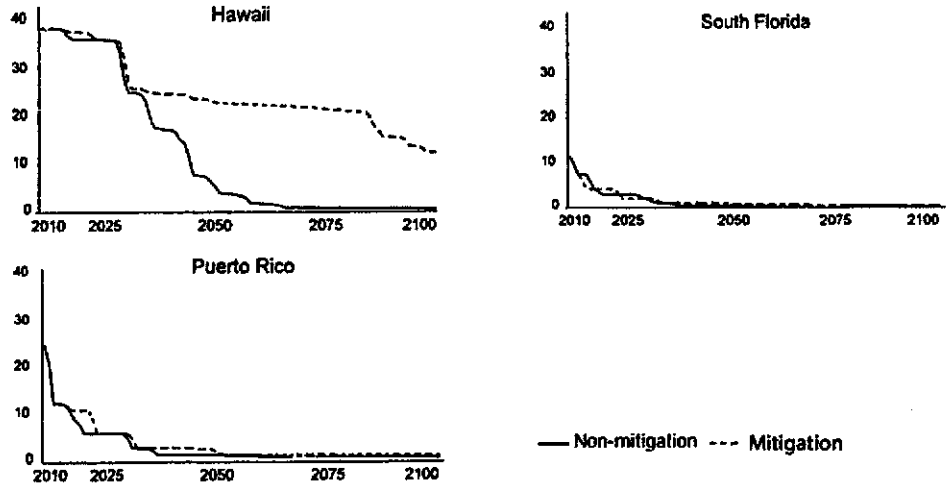
A Increased atmospheric temperature result in melting of sea ice which decreases the amount of sunlight reflected back into space.

B Increased burning of fossil fuels increases atmospheric CO_2 concentration, enhancing the greenhouse effect.

C Melting of glaciers causes an increase in sea levels.

D Increase in atmospheric temperature causes many species to move towards increased altitudes to stay within their optimum temperature range.

30 Some studies reveal that mitigating (reducing) global greenhouse gas emissions have varied effectiveness in reducing negative impact on coral growth. The figure below shows the projected coral reef cover (%) over time (year) in Hawaii (latitude 22.2°N), South Florida (24.5°N) and Puerto Rico (18.2°N) under mitigation and non-mitigation scenarios.



Based on the information given above, which of the following are possible explanations for the projected coral reef cover in the various locations after mitigation?

1 The coral reef cover in Hawaii is projected to improve significantly after mitigation because average sea temperatures there may not be significantly higher than the thermal limit of the corals.
2 It is projected that mitigation in South Florida and Puerto Rico would not significantly improve coral reef because these countries are closer to the equator as compared to Hawaii.
3 Recovery of coral cover after mitigation in South Florida is projected to be negligible because the extent of damage is already very high.

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

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9744/02

Paper 2 Structured Questions

4 September 2019

Candidates answer on the Question Paper.

No Additional Materials are required.

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer all questions in the spaces provided on the Question Paper

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
Total	

This document consists of 24 printed pages.

[Turn over

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

1 **Fig. 1** is a transmission electronmicrograph of part of an animal cell.

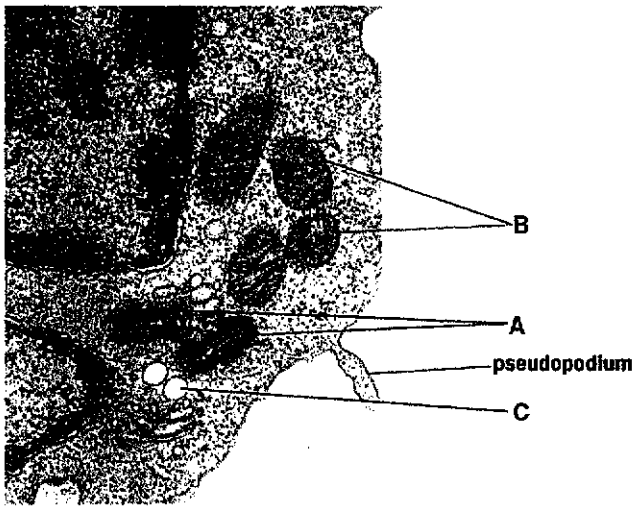


Fig. 1

(a) Identify the organelles labelled **A** and **B**.
In each case, state **two** visible features that enabled your identification.

A

1. .....

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2. .....

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B

1. .....

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2. .....

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[6]

(b) Suggest why structures **B** are of different shapes.

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[1]

(c) Describe the functions of structure **C**.

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[2]

(d) Explain how the structure of membrane allows the formation of pseudopodium.

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[2]

[Total: 11]

2 Starch granules are visible within the chloroplasts. Starch is the most common storage compound of plants. It is composed of amylopectin and amylose.

(a) State **one** role of magnesium ions within chloroplasts.

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[1]

(b) Describe **one** structural similarity and **one** structural difference between amylopectin and amylose.

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[2]

(c) **Fig. 2** shows the monomers of amylopectin.

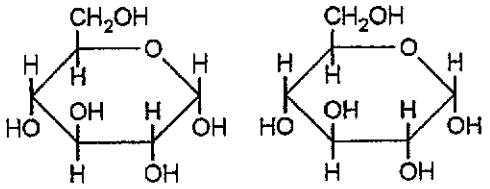

Fig. 2

Draw in the space below **two** possible ways that these molecules can form bonds.

[2]

(d) Explain how the structure of starch makes it suitable for its function.

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[3]

[Total: 8]

3 Enzymes are globular proteins that catalyse metabolic reactions.

(a) Describe the features of globular proteins.

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[2]

(b) **Fig. 3.1** shows a reaction catalysed by the enzyme sucrase.

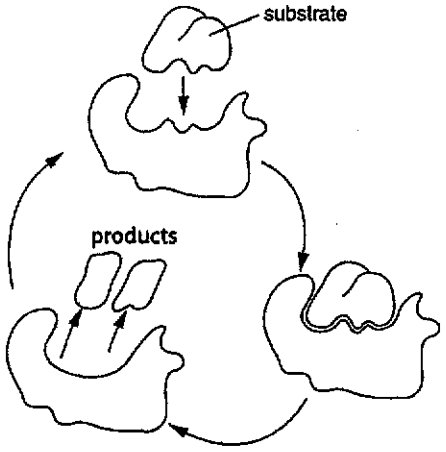

Fig. 3.1

With reference to **Fig. 3.1**,

(i) explain the mode of action of sucrase.

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[3]

(ii) state the products of the reaction.

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[1]

(c) A student investigated the effect of increasing the concentration of sucrose on the rate of activity of sucrase.

Ten test-tubes were set up with each containing 5 cm^3 of different concentrations of a sucrose solution. The test-tubes were placed in a water bath at 40°C for ten minutes. A flask containing sucrase solution was also put into the water bath.

After ten minutes, 1 cm^3 of the sucrase solution was added to each test-tube. The reaction mixtures were kept at 40°C for a further ten minutes.

After ten minutes, the temperature of the water bath was raised to boiling point. Benedict's solution was added to each test-tube. The time taken for a colour change was recorded and used to calculate rates of enzyme activity.

The whole procedure was repeated after adding copper ions to different concentrations of sucrose solutions.

The results are shown in **Fig. 3.2**.

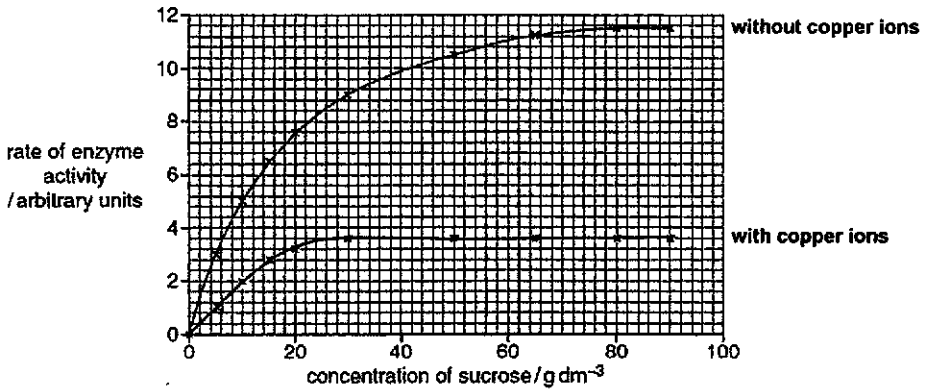

Fig. 3.2

(i) Explain why the temperature of the water was raised to boiling point.

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[2]

(ii) Using the information in **Fig. 3.2**, explain the effect of copper ions on the action of an enzyme, such as sucrase.

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[3]

[Total: 11]

4 In 1941, US geneticist George Beadle proposed the "one gene-one enzyme" hypothesis where each gene is responsible for producing a single enzyme that in turns affects a single step in a metabolic pathway. It was later modified to become the **"one gene-one polypeptide"** hypothesis to include nonenzyme proteins and individual polypeptide chains that are encoded by genes. Post-transcriptional level regulation carried out by alternative splicing makes the modified hypothesis become too simplistic to describe the relationship between genes and proteins.

(a) Descibe how alternative splicing challenges this one gene-one polypeptide hypothesis.

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[2]

8

In eukaryotic cells, gene expression is regulated in a highly coordinated way.

The Ras protein stimulates the cell cycle through a series of reactions. **Fig. 4.1** shows a simple description of the pathway in which the Ras protein acts.

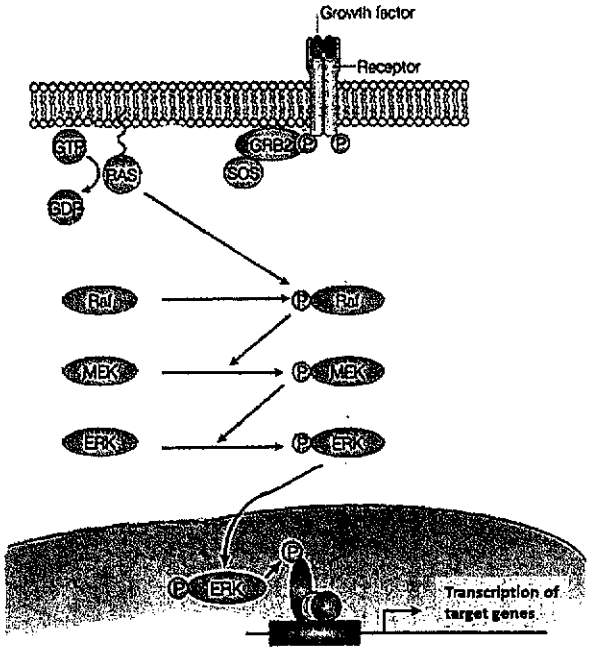

Fig. 4.1

(b) With reference to **Fig. 4.1**, state the level of regulation of the following genes and provide reasons for your answer.

(i) *MEK* gene;

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[2]

(ii) target genes;

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[2]

(c) **Fig. 4.2** below shows the post-translational control gene expression using ubiquitin and proteasome.

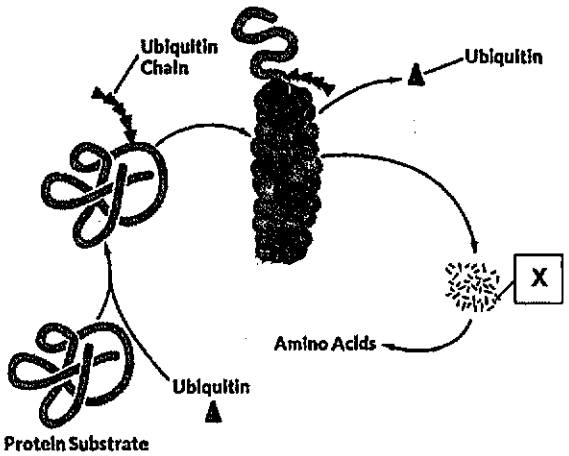

Fig. 4.2

(i) Name molecule **X**.

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[1]

(ii) With reference to **Fig. 4.2**, explain how cellular proteins are degraded using this system.

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[3]

[Total: 10]

5 Bacteria reproduce by the process of binary fission.

(a) Explain the significance of binary fission in bacteria.

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[2]

Researchers have identified a gene that gives bacteria resistance to a type of antibiotics called polymyxins. Despite being discovered around 60 years ago, polymyxins maintained their effectiveness as antibiotics as they were seldom used due to concerns about their toxicity.

In recent years, rampant use of common antibiotics (e.g. penicillin and its derivatives) has led to the emergence of bacterial strains which are resistant to such antibiotics. This has become more and more of a global concern. Polymyxins are now a last line of defense against bacteria because of its previous lack of use.

(b) With reference to the reproductive cycle of bacteriophages, suggest how bacteriophage infections may lead to a spread of antibiotic resistance between bacterial populations.

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[3]

The practice of using bacteriophages to treat bacterial infections has been around for almost a century but it was brought to a standstill after the successful introduction of antibiotics. The universal decline in the effectiveness of antibiotics has generated renewed interest in this century old practice.

A bacteriophage such as a lambda phage can infect an E. coli cell but not a eukaryotic cell.

(c) Describe how the entry of a bacteriophage into an E. coli cell differs from that of an animal virus such as HIV.

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[2]

The replication cycle of the lambda phage in an E. coli cell occurs in two phases, as a prophage or lytically. **Fig. 5** shows that these two phases are controlled by the regulatory proteins **cI** and **Cro**, which are encoded by the virus.

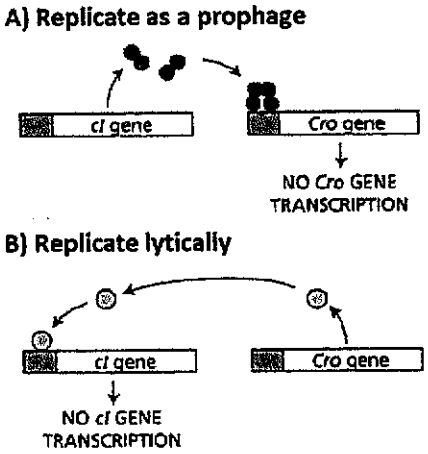

Fig. 5

When bacteria containing a lambda prophage are irradiated with ultraviolet light, the **cI** protein is degraded.

(d) With reference to **Fig. 5**, and your knowledge of bacteriophages, describe the events that occur when the bacteria is irradiated.

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[3]

[Total: 10]

6 The cells in **Fig. 6.1** are from the same organism and look the same.

The cells in **Fig. 6.1(a)** have been produced by mitosis and the cells in **Fig. 6.1(b)** have been produced by meiosis.

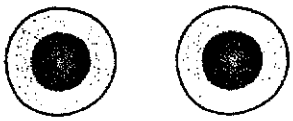

Fig. 6.1(a)

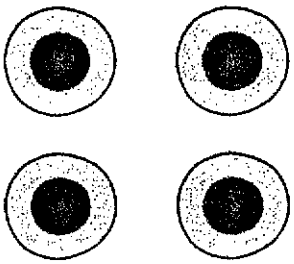

Fig. 6.1(b)

(a) Complete the table to show three differences between cells that have been produced by mitosis compared to cells that have been produced by meiosis.

mitosis	meiosis

[3]

(b) Fig. 6.2 shows the life cycle of a species of brown seaweed.

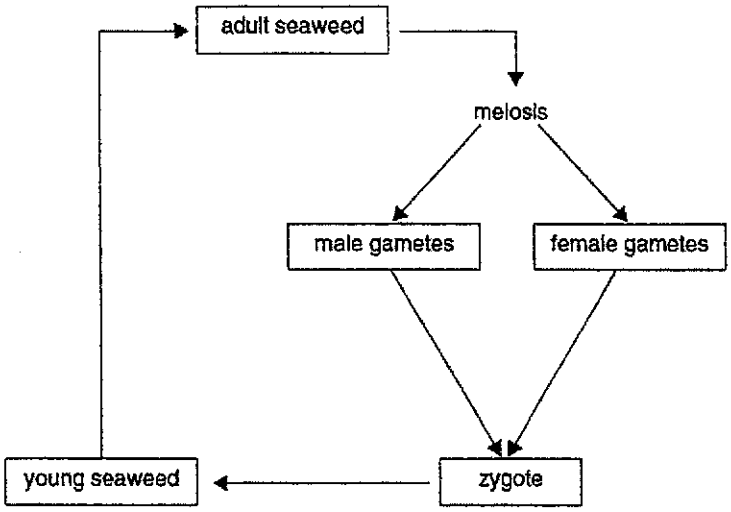

Fig. 6.2

(i) Indicate on **Fig. 6.2**, with the letter **M**, the stage (s) where mitosis occurs. [1]

(ii) DNA replication occurs in cells during interphase before they divide by mitosis. Explain why it is important that replication occurs before mitosis.

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[2]

(iii) Explain why meiosis occurs in the life cycle of this seaweed.

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[3]

[Total: 9]

7 In the sweet pea plant, *Lathyrus odoratus*, one gene codes for flower colour and one gene codes for pollen grain shape.

Flower colour is either purple or red. Pollen grain shape is either long or round.

The inheritance of these genes is an example of **autosomal linkage**.

- The allele **F** for purple flowers is dominant over the allele **f** for red flowers.
- The allele **G** for long pollen grains is dominant over allele **g** for round pollen grains.

(a) Explain the meaning of the term *autosomal linkage*.

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[2]

(b) A dihybrid cross was carried out between homozygous dominant and homozygous recessive sweet pea plant parents to produce the F1 generation.

The offspring from the F1 generation were crossed to produce the F2 generation.

(i) Draw a genetic diagram to show a dihybrid cross between two offspring from the F1 generation. Assume that these genes are closely linked and that there are **no** crossing over events.

[3]

(ii) The actual results of the dihybrid cross are shown in **Table 7.1.**

Table 7.1

phenotypes of F2 offspring	number of individuals
purple flowers, long pollen grains	284
purple flowers, round pollen grains	21
red flowers, long pollen grains	21
red flowers, round pollen grains	55

State how the results support the fact that this is an example of autosomal linkage.

.....

.....

[1]

(c) (i) In a test cross, an individual of **known** genotype is crossed with an individual that has a dominant phenotype but unknown genotype.

State the genotype of the **known** individual in a test cross.

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[1]

(ii) A test cross was carried out with sweet pea plants known to be heterozygous for both flower colour and pollen grain shape. The results of the test cross are shown in **Table 7.2**.

Table 7.2

phenotypes of offspring of test cross	number of individuals
purple flowers, long pollen grains	215
purple flowers, round pollen grains	30
red flowers, long pollen grains	32
red flowers, round pollen grains	210

The result of a test cross can be used to determine a crossover value (COV).
A crossover value is the percentage of the total number of offspring showing recombination.

The crossover value (COV) can be calculated using the formula shown below.

$$\text{COV} = \frac{\text{number of recombinants}}{\text{total number of individuals}} \times 100$$

Calculate the COV from the results shown in **Table 7.2**.

COV = ... %

[2]

(iii) Suggest what information about the relative distance between the linked genes can be gained from crossover values.

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[1]

[Total: 10]

8 Maize, *Zea mays*, is a cereal crop that is adapted for growth at high temperatures. However, it does not cope well with drought.
An investigation was carried out into the effect of low water availability on the activity of mitochondria taken from maize seedlings.

Young seedlings were uprooted and left in dry air for varying periods of time to reduce the water potential of their tissues.

(a) After drying in air, mitochondria were extracted from the tissues of the seedlings. The extracted mitochondria were provided with succinate, which is one of the intermediate compounds in the Krebs cycle, and also with ADP and inorganic phosphate. The rate at which the extracted mitochondria took up oxygen was measured. The results are shown in **Fig. 8.1**.

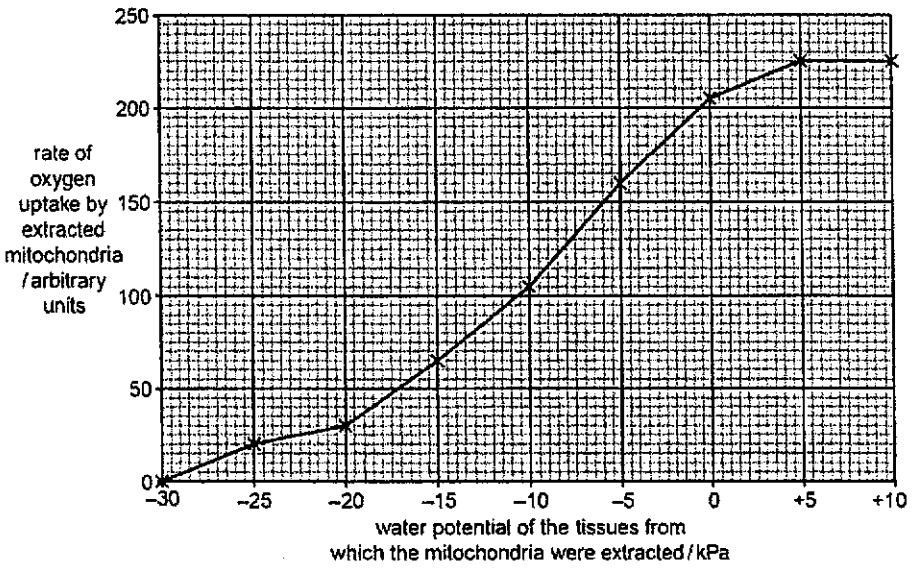

Fig. 8.1

(i) Describe the results shown in **Fig. 8.1**.

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[2]

(ii) The mitochondrion take up oxygen. Explain how this oxygen, plus the succinate, ADP and inorganic phosphate, are used by the mitochondria.

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[3]

(b) A mitochondrion contains DNA and ribosomes and is the organelle in which aerobic respiration takes place.

Suggest the functions of the DNA and ribosomes in a mitochondrion.

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[2]

(c) Some parasitic worms, such as tapeworms, live in a mammalian gut where there is no oxygen.

Suggest how a tapeworm produces ATP in this environment.

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[3]

[Total: 10]

9 The Hawaiian Islands are some of the most isolated volcanic islands in the world. It is made up of a group of islands that are formed at different times. The first birds to have flown to these islands probably arrived millions of years ago from East Asia.

Fig. 9.1 and **Fig. 9.2** show the fossils of two extinct species of goose found on two different Hawaiian islands. The Giant Hawaiian goose was a flightless bird whereas the Woodwalking goose could fly.

Until recently, the evolutionary relationships among Hawaiian goose are known only from bone structures. **Fig. 9.1** shows the skulls and beaks while **Fig. 9.2** shows the wing and leg bones of the giant Hawaiian goose and woodwalking goose.

Giant Hawaiian goose Woodwalking goose

Fig. 9.1

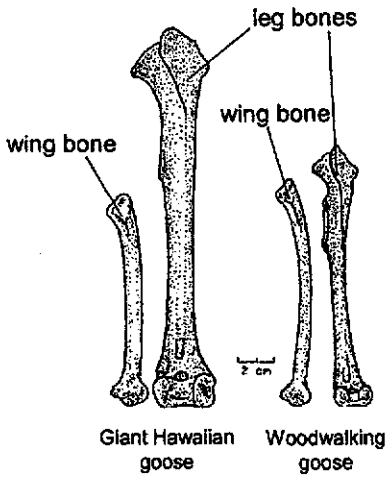

Fig. 9.2

(a) With reference to **Fig. 9.1** and **Fig. 9.2**,

(i) discuss whether the fossil records support Darwin's theory of evolution.

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[2]

(ii) explain how natural selection could have brought about the evolution of the leg bone of the giant flightless Hawaiian goose.

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[4]

Several fossil specimens of both Hawaiian goose species were found and the mean lengths of their skulls, beaks and wing and leg bones were measured. A statistical test was carried out to determine whether there was a significant difference between these means.

(b) (i) State the statistical test that was carried out.

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[1]

(ii) A summary of the results is shown in **Table 9.**

Table 9

mean length of skull / mm		significance of difference
giant Hawaiian goose	woodwalking goose	
89.0	31.2	$p < 0.05$
mean length of beak / mm		significance of difference
giant Hawaiian goose	woodwalking goose	
38.6	18.3	$p < 0.05$
mean length of wing bone / cm		significance of difference
giant Hawaiian goose	woodwalking goose	
7.3	8.2	$p > 0.05$
mean length of leg bone / cm		significance of difference
giant Hawaiian goose	woodwalking goose	
14.6	9.4	$p < 0.05$

Comment on what these results show and suggest explanation for any pattern.

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[4]

[Total: 11]

10 Human Immunodeficiency Virus (HIV) infects cells of the immune system, particularly helper T-lymphocytes and memory helper T-lymphocytes. The onset of disease, which can occur many years later, coincides with a severely lowered primary and secondary immune response, owing to greatly reduced numbers of helper T-lymphocytes in the body.

(a) Explain how the destruction of memory helper T-lymphocytes will contribute to a lowered **secondary** immune response.

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[3]

(b) Tuberculosis (TB) is an important disease worldwide.

Suggest why TB is more likely to be fatal in people who have HIV/AIDS than in those who do not have HIV/AIDS.

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[2]

[Total: 5]

11 Plants have long been regarded as carbon sinks because they take in carbon dioxide for photosynthesis. However, when temperatures rise, plants increase their rate of respiration, resulting in increased carbon dioxide release. Some research has suggested that this could convert forests from a long-term carbon sink to a carbon source, aggravating climate change.

In 2016, a team of scientists conducted a short-term study of five years to find out the net carbon exchange of trees when the temperature was increased. In order to determine this, the increase in leaf respiration at higher temperatures was evaluated using 1000 young trees of 20 different boreal and temperate tree species grown in an open-setting.

Fig. 11 showed the observed data and expected data that had been derived from mathematical model projection using computer simulation.

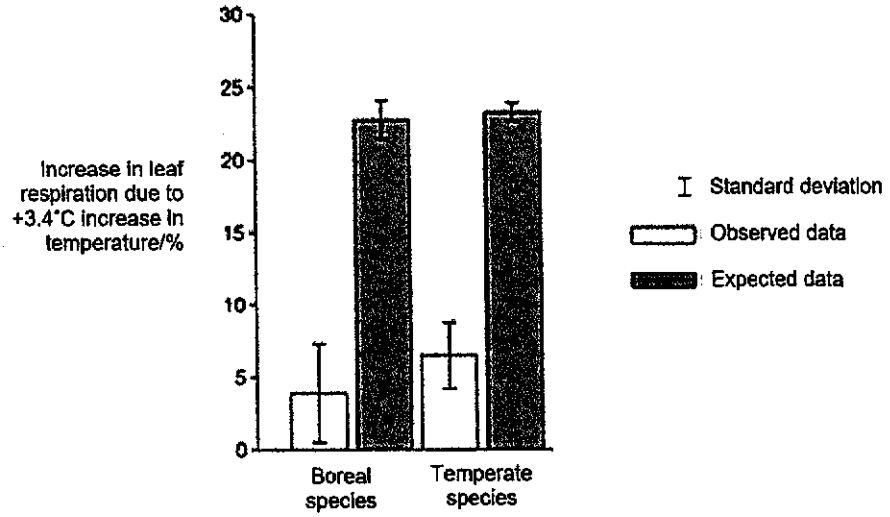

Fig. 11

(a) With reference to **Fig. 11**, describe one difference between the observed and expected data.

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[2]

(b) In **Fig. 11**, the observed data shows a difference in the increase in leaf respiration between boreal and temperate tree species. Suggest why this difference is not significant.

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[1]

(c) Based on the results of the study, comment on whether forests will remain as carbon sinks or be converted to carbon sources if temperatures rise.

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[2]

[Total: 5]

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

20 September 2019

Additional Materials: Answer Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions in the spaces provided on the Question Paper

Section B

Answer any **one** question on the separate Answer Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
Total	

This document consists of 13 printed pages.

[Turn over

Section A

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

1 In Africa, *Anopheles gambiae* is one of the best-known mosquito vector species because of its role in the transmission of the dangerous malarial parasite – *Plasmodium falciparum*.

Molecular analyses reveal that there are two forms of *A. gambiae*, the **M** and **S** molecular forms. These two forms are morphologically identical but show widespread molecular differences throughout their genomes.

The **M** and **S** molecular forms of *A. gambiae* are found in and around irrigated rice fields located within the same humid savannahs of western Africa. The **M** form is associated with larger permanent breeding sites mostly consisting of rice paddies, whereas the **S** form is found to depend on temporary, rain-filled breeding sites. Although interbreeding between **M** and **S** forms yields fertile progeny, **M-S** hybrids are rarely observed in nature.

(a) (i) Describe how the molecular differences between the **M** and **S** forms of *A. gambiae* could have come about.

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[2]

(ii) Suggest how the level of molecular differences between the two forms of *A. gambiae* could have been determined.

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[1]

(iii) One advantage of molecular analyses is the ability to detect evolutionary changes between populations even though they may look morphologically similar or identical.

Other than the advantage stated above, describe **two** advantages of molecular analyses in classifying organisms.

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[2]

(b) Explain the type of speciation *A. gambiae* is undergoing.

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[3]

(c) *A. gambiae* go through four stages in its life cycle.

Complete **Fig. 1.1** to show these stages.

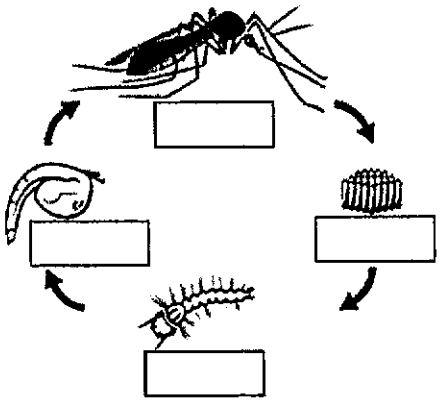

Fig. 1.1

[1]

(d) *Anopheles* mosquitoes thrive in regions with warm temperatures, humid conditions, and high rainfall. Thus, tropical and subtropical areas are ideal. Warm temperatures are also required for malarial parasites to complete their growth cycle within the mosquitoes.

Climate change due to global warming is expected to cause latitudinal and altitudinal temperature increases. Such a temperature increase will alter the biology and ecology of many mosquito vectors and subsequently, the dynamics of the diseases they transmit.

(i) Explain how increased temperatures could impact the biology of insects like mosquitoes.

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[2]

(ii) Globally, average temperatures could increase by more than 2°C by the end of the 21st century.

Suggest **and** explain the effect this change in temperature will have on the distribution of malaria across the world.

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[2]

5

A research team investigated the activity of two forms of catalase, **P** and **Q**, extracted from *A. gambiae*. The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism, into oxygen and water. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.

The results are shown in **Fig. 1.2.**

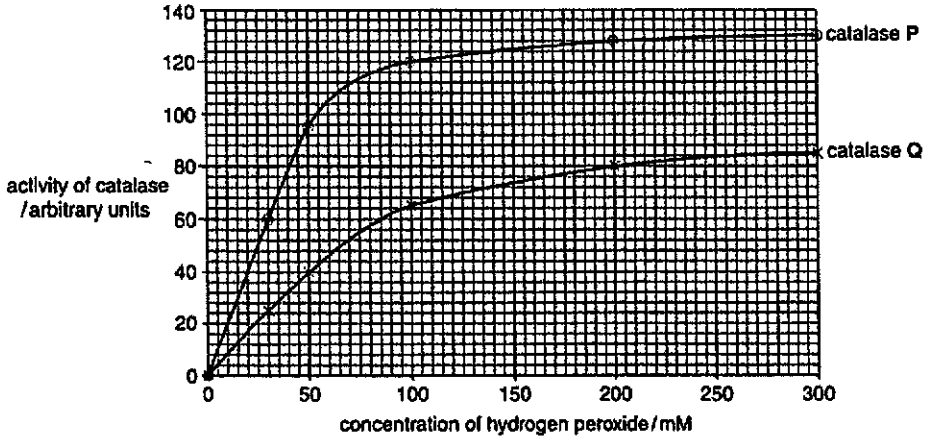

Fig. 1.2

(e) With reference to **Fig. 1.2**, describe **and** explain the effect of increasing the concentration of hydrogen peroxide on the activity of catalase **P**.

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[4]

(f) Each molecule of catalase consists of four identical polypeptides. The two forms of catalase in *A. gambiae* differ by only one amino acid at position 2 in the amino acid sequence. Catalase **P** has serine and catalase **Q** has tryptophan.

Suggest how the difference in one amino acid is responsible for the lower activity of catalase **Q** compared with catalase **P**.

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[2]

(g) Blood is a rich source of proteins for mosquitoes. Female mosquitoes feed on blood in order to produce their eggs. After feeding, the metabolic rate increases for egg production.

(i) The researchers allowed female mosquitoes to feed on blood. They found that female mosquitoes with only catalase **P** produced more eggs than those with only catalase **Q**.

Suggest why there is a difference in egg production between the two types of *A. gambiae*.

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[2]

(ii) The proteins in blood are broken down into amino acids and absorbed by the epithelial cells in the mosquitoes' midgut. Amino acids require specific carrier proteins to enter cells.

Explain why carrier proteins are required in cell surface membranes for the transport of amino acids.

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[2]

(h) Other than the transport of substances into and out of cells, describe **two** roles of cell surface membranes.

1

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2

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[2]

[Total: 25]

2 The coat colour of Norwegian cattle is mainly determined by the distribution of two pigments: red and black. Both pigments are produced by the action of the enzyme tyrosinase in cells called melanocytes. A low level of activity of the enzyme leads to the production of red pigment, whilst a high activity allows only black pigment production. The activity of the enzyme is increased by melanocyte stimulating hormone (MSH), which combines with an MSH receptor. The receptor is coded for by the **E** locus, which has three alleles, E^D, E^A and **e**. E^D and E^A each give a receptor with a different activity. No receptor is produced by the recessive allele, **e**.

The dominant allele of a second gene, the **A** locus, codes for a protein which binds to and blocks the MSH receptors coded for by E^A, thus preventing stimulation of tyrosinase activity in melanocyte. The receptor coded for E^D is insensitive to the protein coded for at the **A** locus.

The effects of the different alleles of the two loci are summarised in **Table 2.1**.

Table 2.1

E locus	
genotype	*MSH receptor*
E^DE^D or E^De	insensitive to A locus blocking protein
E^AE^A or E^Ae	Sensitive to A locus blocking protein
ee	none

A locus	
genotype	*Protein which blocks MSH receptor*
AA or Aa	Present
aa	Absent

(a) (i) State the name given to interaction between gene loci, such as that between the **E** and **A** loci.

.....

.....

[1]

(ii) Explain why animals with the genotype E^AE^AAA have red coats.

.....

.....

.....

.....

[2]

(iii) Predict the coat colours of animals with the following genotypes:

eeaa .....

E^Aeaa .....

E^DeAa .....

[3]

Allele E^A differs from E^D by a single base substitution and **e** differs from E^A by a single base deletion.

(b) Suggest how these mutations might result in differences in the MSH receptor.

.....

.....

.....

.....

[2]

DNA was extracted from the frozen semen of six bulls with different genotypes at the **E** locus. The DNA from each animal was separately digested with two different restriction enzymes **P** and **Q**. The products of each digestion were separated on a gel. The banding patterns produced with respect to this locus are shown in **Fig. 2.1**.

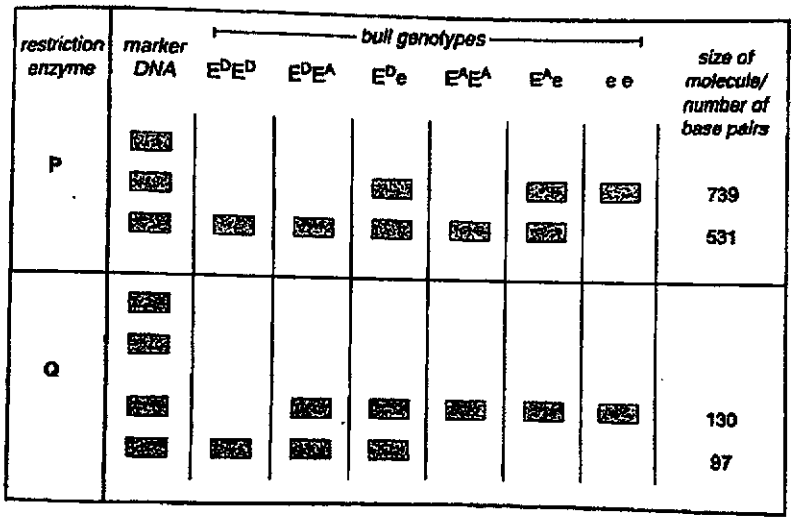

Fig. 2.1

(c) Explain briefly how the products of digestion of DNA with restriction enzymes can be separated on a gel.

.....

.....

.....

.....

[2]

(d) Suggest why the products of digestion of DNA from the same animal are different when a different restriction enzyme is used.

.....

.....

.....

.....

[2]

(e) State which genotypes can be identified by using each of the two restriction enzymes.

P

.....

Q

.....

[2]

[Total: 14]

3 B-lymphocytes respond to the presence of an antigen by dividing as shown in Fig. 3.1.

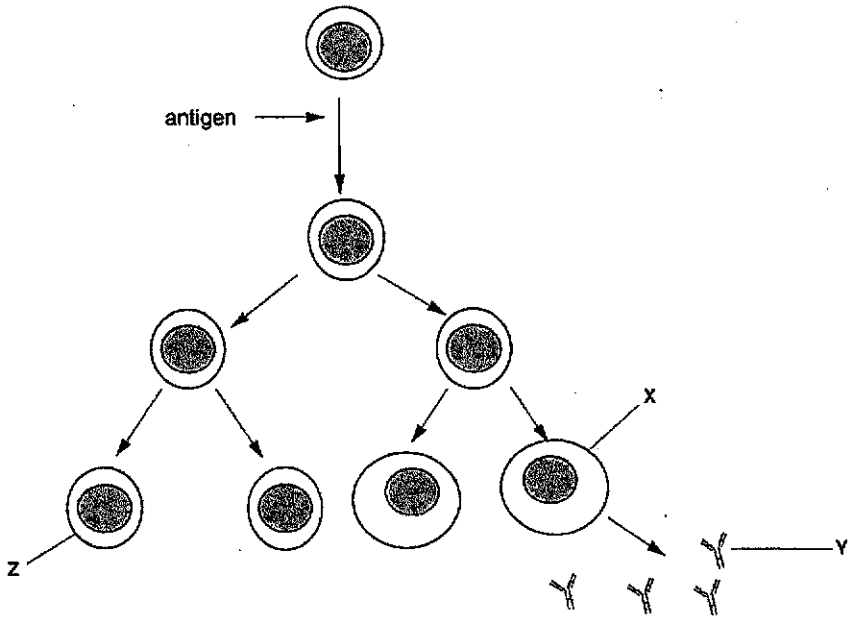

Fig. 3.1

(a) Describe how Y are released from cell X.

.....

.....

.....

.....

[2]

Cell Z has an important role in the immune system.

(b) Explain the role of cell Z.

.....

.....

.....

.....

.....

.....

[3]

Fig. 3.2 shows the sequence of events in one the cell signalling pathways when a B-lymphocyte encounters an antigen.

LYN and **SYK** are tyrosine kinases.

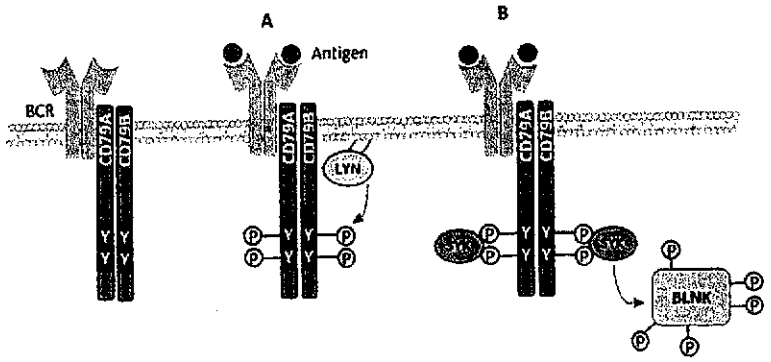

Fig. 3.2

(c) With reference to the main stages of cell signalling and **Fig. 3.2**,

(i) describe stages **A** and **B**.

A

.....

.....

.....

.....

B

.....

.....

.....

.....

[4]

(ii) suggest how the signal can be terminated.

.....

.....

.....

.....

[2]

[Total: 11]

Section B

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

4 (a) Discuss why life would be impossible without ATP. [13]

(b) Describe the effects of different types of mutations on the proteins of eukaryotes. [12]

[Total: 25]

5 (a) Discuss why intracellular enzymes are essential to life. [13]

(b) Describe how variation arises and how recessive alleles are preserved in a population. [12]

[Total: 25]

H

NANYANG JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9744/04

Paper 4 Practical

28 August 2019

Candidates answer on the Question Paper
Additional Materials: As listed in the Confidential Instructions

2 hour 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper

Shift
Laboratory

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.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
1	
2	
Total	

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

[Turn over

1 You are provided with a solution, labelled **E**, containing an enzyme which coagulates (clots) milk. Enzyme **E** hydrolyses (breaks) peptide bonds between certain amino acids in a protein found in milk and this results in the coagulation of the milk. Calcium ions are required for this coagulation.

You are required to:

- carry out a trial test to think about sources of error
- make simple (proportional) dilutions of the proteins in the milk, **M**
- record the time taken to reach end point for each of the concentrations of M
- estimate the concentration of milk protein in **U**.

When a mixture of milk, calcium chloride solution and **E** is gently rotated in a test-tube the coagulation goes through the stages shown in Fig. 1.1.

Stage **3** is the end-point of the enzyme-catalysed coagulation.

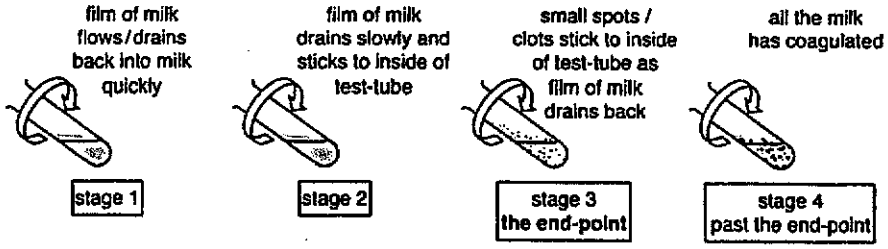

Fig. 1.1

The time taken to reach **end-point** gives an indication of the concentration of protein in milk.

You are provided with:

Table 1.1

labelled	contents	hazards	volume / cm^3
C	10% calcium chloride solution	harmful irritant	20
W	distilled water	none	100
M	milk	none	100
E	1% enzyme solution	harmful irritant	20
U	milk with an unknown concentration of protein	none	20

If **C** or **E** comes into contact with your skin, wash off immediately under cold water. It is recommended that you wear suitable eye protection.

Before proceeding further, use the beaker labelled **hot water** to collect approximately 200cm^3 of hot water from where it is provided in the laboratory.

You are required to carry out a trial test (step 1 to step 16) before you start your investigation.

Read step 1 to step 16 before proceeding.

Proceed as follows:

1 You are provided with a beaker labelled **water-bath**. Use the hot and cold water to set up a water-bath in this beaker. The starting temperature of the water-bath should be between 35°C and 40°C.

You will **not** need to maintain this temperature during steps 2 to 15.

2 Put 10cm^3 of **M** into a test-tube.

3 Repeat step 2 so that you have three test-tubes containing **M**.

4 Put 1cm^3 of **C** into each test-tube.

5 Gently shake each of the test-tubes to mix **M** and **C**.

6 Take the temperature of the water-bath and record this temperature in **(a)(ii)** on page 5.

7 Put the test-tubes into the water-bath and leave for at least 3 minutes.

(a) (i) Explain why the test-tubes are left in the water-bath for at least 3 minutes in step 7.

.....

.....

..... [1]

8 Remove one of the test-tubes from the water-bath.

The process of coagulation will start when **E** is added to the test-tube.

9 Put 1cm^3 of E into the test-tube, so that it runs down the side of the test-tube and forms a layer on the surface of the mixture, as shown in Fig. 1.2.

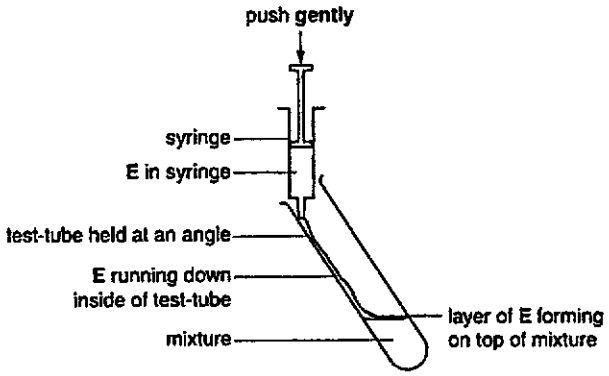

Fig. 1.2

10 Start timing.

11 Hold the test-tube over a piece of black card on the table as shown in Fig. 1.3.

12 Gently rotate the test-tube to form a film of milk on the inside of the test-tube.

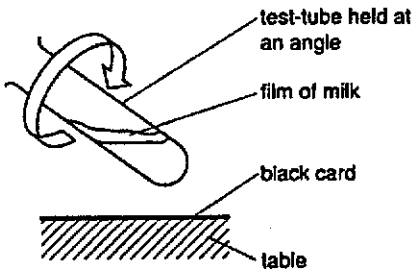

Fig. 1.3

13 Observe the film until the end-point is reached (stage 3 in Fig. 1.1). Ignore any small bubbles on the inside of the test-tube. Stop timing.

14 Record in **(a)(iii)** the time taken to reach the end-point.

If the end-point has not been reached in 4 minutes, stop the experiment and record 'more than 240'.

15 Repeat step 8 to step 14 with each of the other two test-tubes in the water-bath.

16 Take the temperature of the water-bath when the final test-tube has been removed and record this in **(a)(ii)**.

(ii) Temperature may be a source of error in this investigation.

State the temperatures of the water-bath.

temperature of water-bath taken in step 6 ..... °C

temperature of water-bath taken in step 16 ..... °C

Explain whether the temperature of the water-bath is a significant source of error in this investigation.

.....

.....

..... [1]

(iii) Record your results in an appropriate table.

[2]

(iv) A significant source of error for this investigation is deciding when the end-point is reached.

Suggest **one** advantage of carrying out this trial test **before** carrying out the investigation.

.....

..... [1]

(v) You are required to prepare different concentrations of the proteins in milk, **M**.

M is undiluted milk and is to be referred to as 100% milk.

You are required to make a simple (proportional) dilution of **M**, which reduces the concentration of **M** by **20%** between each successive dilution. You will also need to make a 10% concentration.

You will need to prepare 20cm^3 of each concentration.

You will require these different concentrations of milk for both part (a) and (b) of this question.

Table 1.2 shows how to make up two of the concentrations you will use, 100% and 10%.

Decide which other concentrations of milk to prepare using simple (proportional) dilutions of **M** and complete Table 1.2.

Table 1.2

volume of **M** / cm^3	volume of distilled water, **W** / cm^3	concentration of milk/ %
20.0	0.0	100
2.0	18.0	10

[2]

17 Prepare the concentrations of milk as decided in **(a)(v)**.

18 Adjust the temperature of the water-bath so that it is between 35°C and 40°C.
You will **not** need to maintain this temperature during step 19 to step 24.

19 Put 10cm^3 of the lowest concentration of milk into a test-tube.

Repeat step 19 with each of the other concentrations of milk that you have prepared and with 100% milk.

Do not *dispose remaining volumes of milk. You will require them in part (b) of this question.*

20 Put 1cm^3 of **C** into each test-tube.

21 Gently shake each of the test-tubes to mix the milk and **C**.

22 Put the test-tubes in the water-bath and leave for at least 3 minutes.

While you are waiting read step 8 to step 13.

23 After 3 minutes remove one of the test-tubes from the water-bath. Add 1cm^3 of **E** as in step 9, then repeat step 10 to step 13 and record in **(a)(vi)** the time taken to reach the end-point.

24 Repeat step 24 with each of the other test-tubes.

(vi) Record your results in an appropriate table for the known concentrations of milk.

[4]

You are now required to estimate the protein concentration of **U**.

25 Repeat the experiment with **U**.

Record in **(a)(vii)** the time taken to reach end-point for **U**.

(vii) State the time taken for **U** to reach end-point.

.....

[1]

(viii) Complete Fig. 1.4, using arrows and labels, to show the position on the line of each of the percentage concentrations of milk decided in Table 1.2.

Put the label **U** on Fig. 1.4 to show an estimate of the concentration of milk which provides a measure of the proteins in U, using the result in **(a)(vii)**.

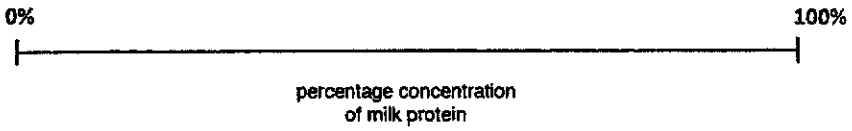

Fig. 1.4

[2]

(ix) Suggest and explain a suitable control experiment that could be used in this investigation.

.....

.....

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.....

.....
[2]

(b) A student suggested that determining protein concentration via the enzyme-catalysed coagulation was too time consuming and there should be a faster method to estimate protein concentration in milk.

You have been provided with the following, which you **must** use:

- Biuret's solution
- spotting tile
- a chart labelled **"colour chart"** provided on the bench

You may use any solutions and apparatus that have been provided.

Plan **and** carry out a method to estimate the concentration of milk protein in **U**.

(i) Outline the steps in your method.

.....

.....

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.....

.....

.....

.....

[3]

(ii) Record your results in a suitable format in the space provided.

[3]

(iii) Complete Table 1.3 to suggest:

- significant sources of error in your procedure
- improvements to reduce these errors.

Table 1.3

significant source of error	improvement

[4]

(c) Another student investigated the effect of temperature on the activity of enzyme **E**, by measuring the percentage coagulation of the milk.

(i) Describe how the temperature could be changed.

.....

.....

.....

.....

.....

[2]

The results are shown in Table 1.4.

Table 1.4

temperature / °C	percentage coagulation of the milk
8.5	7
28.0	63
35.5	84
41.0	92
50.0	39

(ii) Plot a graph of the data in Table 1.4 on the grid in Fig. 1.4.

Use a sharp pencil for drawing graphs.

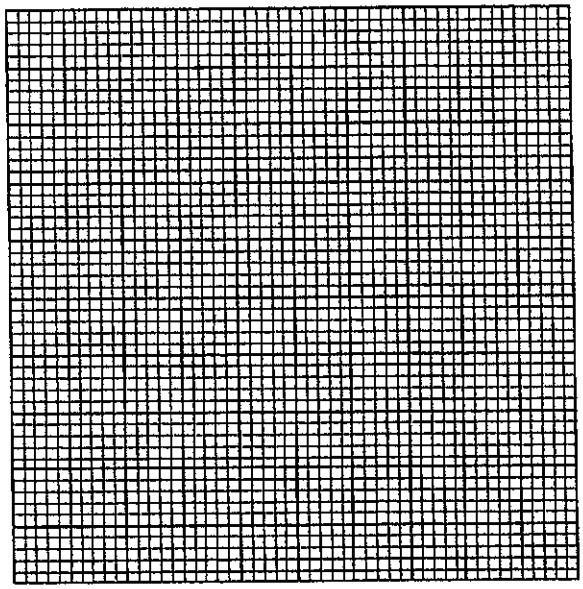

Fig. 1.4

[4]

(iii) Suggest explanations for the results between 35°C and 45°C.

.....

.....

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.....

.....

[3]

[Total: 35]

2 **J1** is a slide of a stained transverse section through a plant leaf.

You are not expected to be familiar with this specimen.

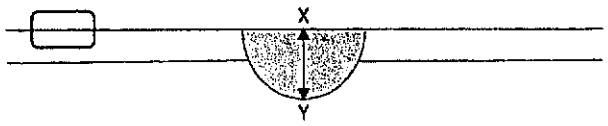

Fig. 2.1

You are required to use a sharp pencil for drawings.

(a) (i) Draw a large plan diagram of the section of the leaf (midrib) shown by the shaded area in Fig. 2.1.

A plan diagram shows the arrangement of different tissues. Your drawing should show the correct shape and proportions of the different tissues.

No cells should be drawn.

Labels are **not** required.

[3]

(ii) Use the eyepiece graticule to measure the actual thickness of leaf at position shown by the line **X – Y** in Fig. 2.1.

Show your working.

Distance **X – Y** ..... [2]

(iii) Observe the upper epidermis at the top of the leaf on **J1** shown by the rectangle in the Fig. 2.1.

Select one group of **three** cells with:

- two cells from the upper epidermis
- one adjacent (touching) cell from the tissue below.

Each cell of the group must touch at least one of the other cells.
Make a large **labelled** drawing of this group of **three** cells.
Label a structure that produces ATP.

[5]

An eyepiece graticule scale can be used to measure cells. To obtain an actual length the eyepiece graticule scale must be calibrated against a stage micrometer. However, to obtain values for calculating a ratio, it is **not necessary** to calibrate the eyepiece graticule scale.

(iv) Observe **J1** using the ×40 objective lens.

Use the eyepiece graticule scale to find the mean width of the

- cells at the upper epidermis
- cells from the tissue below the upper epidermis.

State the ratio of the mean width of the cells at the upper epidermis to the mean width of the cells from the tissue below the upper epidermis.

You may lose marks if you do not show all the steps in finding the ratio.

ratio ..... [3]

(b) Fig 2.2 is a photomicrograph of a stained transverse section through part of a leaf from a different type of plant.

You are not expected to be familiar with this specimen.

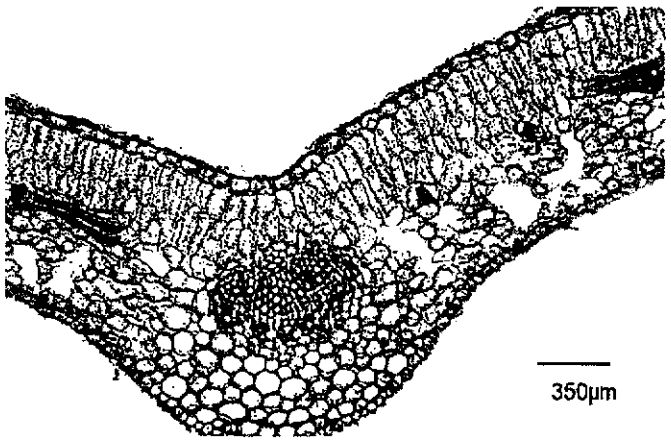

Fig. 2.2

(i) Calculate the magnification of Fig. 2.2 using the scale bar.

You may lose marks if you do not show your working or if you do not use appropriate units.

magnification ×..... [3]

(ii) There are observable differences between the leaf sections in Fig. 2.2 and **J1**. Identify three differences between them.

For each of the three differences, draw one label line to a feature in Fig. 2.2 that shows the difference. Label the three differences **D**, **E** and **F**.

Complete Table 2.1 to describe the difference between the leaf sections for each of these **three** features.

Table 2.1

Feature	Fig. 2.2	J1
D		
E		
F		

[4]

[Total: 20]

21

Qns	Ans	Qns	Ans
1	B	16	D
2	C	17	C
3	B	18	D
4	D	19	B
5	D	20	A
6	A	21	D
7	B	22	C
8	A	23	C
9	A	24	B
10	B	25	D
11	C	26	D
12	B	27	C
13	A	28	D
14	A	29	A
15	B	30	B

BP~181

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME **ANSWERS**

CLASS

BIOLOGY

9744/02

Paper 2 Structured Questions

September 2019

Candidates answer on the Question Paper.

No Additional Materials are required.

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
Total	

This document consists of 21 printed pages and 1 blank page.

[Turn over

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

1 **Fig. 1** is a transmission electronmicrograph of part of an animal cell.

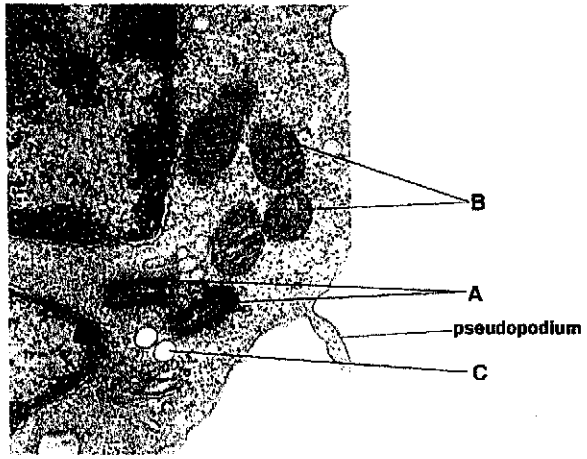

Fig. 1

(a) Identify the organelles labelled **A** and **B**.
In each case, state **two** visible features that enabled your identification.

Structure **A** Centrioles @ centriole

Feature 1

Centrioles exist as a pair of rod-like structures

Feature 2

9 sets of triplet microtubules arranged in a ring

Structure **B** Mitochondria @mitochondrion

Feature 1

double membrane

Feature 2

highly folded cristae / inner membrane

[6]

(b) Suggest why structures **B** are of different shapes.

idea that the sections are orientated differently / cut in different planes / cut at different angles / A is a cross section / AW, and B is a longitudinal section / AW

mitochondria show a variety of, sizes / shapes ;

mitochondria, are flexible / change shape ;

A and B are of, different ages / stages of development ;

[1]

(c) Describe the functions of structure **C**.

C lysosome, (Golgi / secretory) vesicle;

Secretory vesicles containing hydrolytic enzymes bud off / pinch off the Golgi apparatus and move through the cytosol via cytoskeleton towards the cell surface membrane.

Vesicle membrane fuses with cell surface membrane and release contents via exocytosis

OR

Lysosome contains hydrolytic enzymes and remains in cells. The lysosome membrane fuses with membrane of the phagocytic vesicle containing the food/ foreign particle.

Hydrolytic enzymes in lysosomes digest the contents into soluble products. These soluble products diffuse into the cytoplasm for cell use.

[2]

(d) Explain how the structure of membrane allows the formation of pseudopodium.

Fluidity of phospholipid bilayer/ membrane allows change of shape/ extension of pseudopodium / phospholipids can move;

Weak hydrophobic interactions between phospholipid fatty acid tails /

Presence of cholesterol regulates fluidity /

Unsaturated fatty acids creates kinks in the fatty acid tails prevent close packing;

AVP: Presence of glycolipids / glycoproteins / receptors which allow for extension of psueduopodia for receptor-mediated endocytosis;

[2]

[Total: 11]

Starch granules are visible within the chloroplasts. Starch is the most common storage compound of plants. It is composed of amylopectin and amylose.

(a) State **one** role of magnesium ions within chloroplasts.

1 for chlorophyll, structure / synthesis / formation / AW
2 for ATP functioning A required for energy transfers
3 for enzyme, functioning / cofactor
4 signalling ion / regulates carbon fixation
5 for, DNA / RNA, synthesis
6 stabilises, DNA / RNA, structure
7 required in, translation / joining, small and large subunits (of ribosomes)

[1]

(b) Describe **one** structural similarity and **one** structural difference between amylopectin and amylose.

Similarities
1. Both consists of α -glucose molecules.
2. Both are helical
Differences
1 amylopectin branched vs amylose unbranched
2. amylose (α) 1 – 4 linkages vs 1 – 4 and 1 – 6 linkages in amylopectin

[2]

(c) **Fig. 2** shows the monomers of amylopectin.

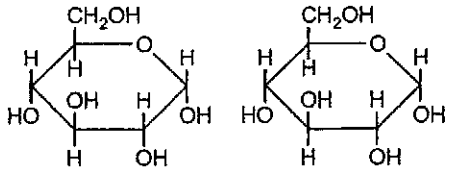

Fig. 2

Draw in the space below **two** possible ways that these molecules can form bonds.

glycosidic bond shown as forming between OH on C1 and OH on C4 ;
glycosidic bond shown as forming between OH on C1 and OH on C6 ;

[2]

(d) Explain how the structure of starch makes it suitable for its function.

amylose, spiral / spiralled / helix / helical ; R α-helix R coiled
amylopectin branched ;
compact / AW ;
(so) insoluble / osmotically inactive / inert / ref to water potential;
ref to branching of amylopectin providing, free ends / easy mobilisation ;
(amylose / amylopectin / starch) contain glucose for immediate use as respiratory substrate (on hydrolysis) ;
Ref to energy storage molecule;
easily formed / easily recovered or mobilised ;

[3]
[Total: 8]

3 Enzymes are globular proteins that catalyse metabolic reactions.

(a) Describe the features of globular proteins.

Spherical/ ball-shaped @ circular/ round

Has a tertiary structure ® 3D

Hydrophilic / polar R group on the outside + hydrophobic / non-polar R group in its interior

Water soluble;

[2]

(b) **Fig. 3.1** shows a reaction catalysed by the enzyme sucrase.

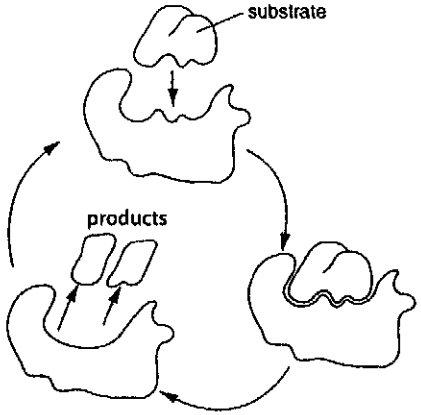

Fig. 3.1

With reference to **Fig. 3.1**,

(i) explain the mode of action of sucrase.

1 (shape of) active site, gives specificity / complementary in shape to substrate; A 'lock and key' / induced fit R 'same shape'

2 further detail of substrate binding to active site ;

3 forms, enzyme-substrate / E-S, complex ;

4 causes stress in substrate / AW ;

5 lowers activation energy ;

6 not used up in reaction / remain unchanged / reusable ;

7 high turnover number / catalyse many reactions per unit time ;

[3]

(ii) state the products of the reaction.

fructose and glucose

[1]

(c) A student investigated the effect of increasing the concentration of sucrose on the rate of activity of sucrase.

Ten test-tubes were set up with each containing 5 cm^3 of different concentrations of a sucrose solution. The test-tubes were placed in a water bath at 40°C for ten minutes. A flask containing sucrase solution was also put into the water bath.
After ten minutes, 1 cm^3 of the sucrase solution was added to each test-tube. The reaction mixtures were kept at 40°C for a further ten minutes.

After ten minutes, the temperature of the water bath was raised to boiling point. Benedict's solution was added to each test-tube. The time taken for a colour change was recorded and used to calculate rates of enzyme activity.

The whole procedure was repeated after adding copper ions to different concentrations of sucrose solutions.

The results are shown in **Fig. 3.2**.

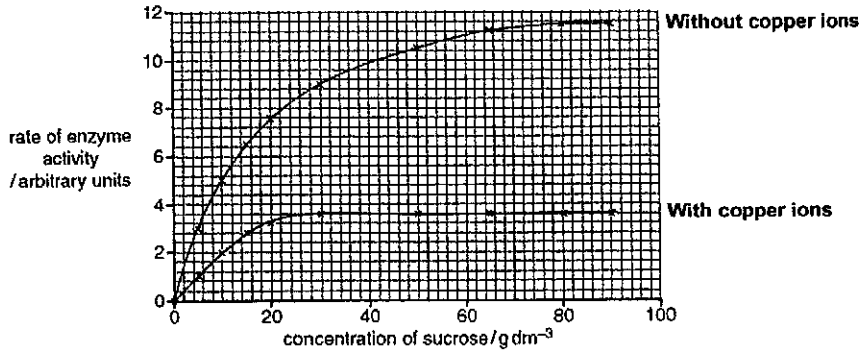

Fig. 3.2

(i) Explain why the temperature of the water was raised to boiling point.

to stop the reaction ; R 'stop it working'

by denaturing, the enzyme / sucrase ; R incorrect context

A 'change shape of active site' to make the Benedict's solution, react / AW ;

[2]

(ii) Using the information in **Fig. 3.2**, explain the effect of copper ions on the action of an enzyme, such as sucrase.

(copper ions act as enzyme) inhibitor ; R competitive inhibitor

non-competitive (inhibition) Cu2+, binds with enzyme at site other than active site ;

active site shape / tertiary structure / 3D shape, changes ;

active site no longer accepts substrate / enzyme-substrate complex not formed / AW ;

independent of substrate concentration / increase in substrate concentration has no effect / AW ;

comparative rates quoted from Fig. 2.2 ; e.g. max, 11.6 v 3.6 au

AVP ; e.g. actual rate depends on the relative concentration of inhibitor / AW Vmax not reached effect of ion presence on tertiary structure

[3]

[Total: 11]

4 In 1941, US geneticist George Beadle proposed the "one gene-one enzyme" hypothesis where each gene is responsible for producing a single enzyme that in turns affects a single step in a metabolic pathway. It was later modified to become the **"one gene-one polypeptide"** hypothesis to include nonenzyme proteins and individual polypeptide chains that are encoded by genes. Post-transcriptional level regulation carried out by alternative splicing makes the modified hypothesis become too simplistic to describe the relationship between genes and proteins.

(a) Describe how alternative splicing challenges this one gene-one polypeptide hypothesis.

1. Spliceosomes are involved in excision of introns and some exons, and joining of remaining exons giving rise to different combinations of exons;
2. One gene produces mature mRNA with different combinations of exons, hence giving different proteins/protein isoforms;

[2]

In eukaryotic cells, gene expression is regulated in a highly coordinated way.

The Ras protein stimulates the cell cycle through a series of reactions. **Fig. 4.1** shows a simple description of the pathway in which the Ras protein acts.

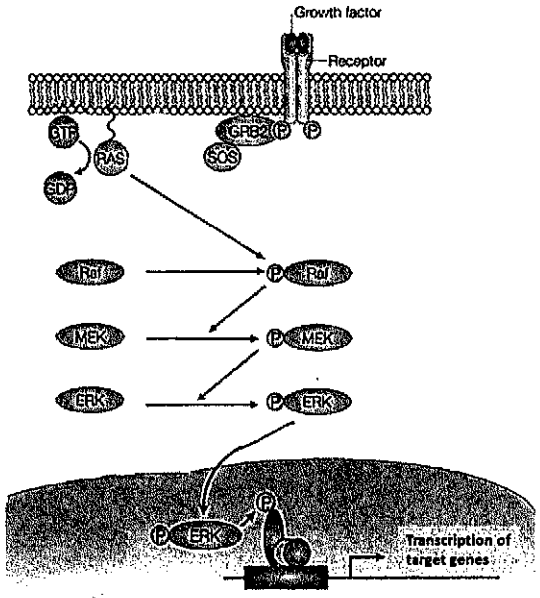

Fig. 4.1

(b) With reference to **Fig. 4.1**, state the level of regulation of the following genes and provide reasons for your answer.

(i) *MEK* gene;

Post translational;

Phosphorylation by Raf (kinase);

[2]

(ii) target genes;

transcriptional;

Activated/ phosphorylated ERK phosphorylates transcription factor which binds to promoter/ enhancer switching on transcription/ upregulating transcription;

[2]

(c) **Fig. 4.2** below shows the post-translational control gene expression using ubiquitin and proteasome.

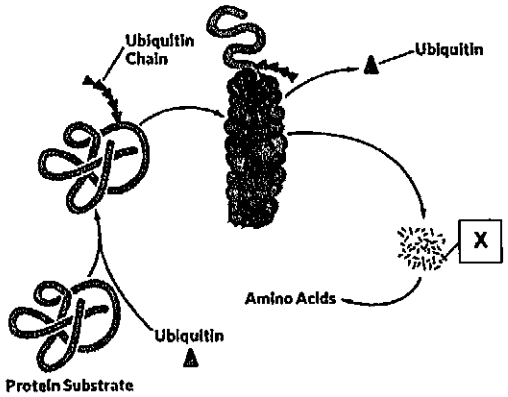

Fig. 4.2

(i) Name molecule **X**.

Short peptides;

[1]

(ii) With reference to **Fig. 4.2**, explain how cellular proteins are degraded using this system.

Proteins selected for degradation are tagged with/ bind to ubiquitin / multiple ubiquitin molecules;

Target proteins tagged with ubiquitin enters/ binds to proteasomes;

Enzymes of proteasomes hydrolyse peptide bonds of protein into small peptides;

Which can be further hydrolysed into amino acids in the cytosol;

Ubiquitin molecules are released and reused;

[3]

[Total: 10]

5 Bacteria reproduce by the process of binary fission.

(a) Explain the significance of binary fission in bacteria.

Ref. asexual reproduction for unicellular organism

Ensuring that offspring are genetically identical to the parent / Desirable alleles/traits are passed down

Rapid increase in cell numbers (under favourable conditions)

[2]

Researchers have identified a gene that gives bacteria resistance to a type of antibiotics called polymyxins. Despite being discovered around 60 years ago, polymyxins maintained their effectiveness as antibiotics as they were seldom used due to concerns about their toxicity.

In recent years, rampant use of common antibiotics (e.g. penicillin and its derivatives) has led to the emergence of bacterial strains which are resistant to such antibiotics. This has become more and more of a global concern. Polymyxins are now a last line of defense against bacteria because of its previous lack of use.

(b) With reference to the reproductive cycle of bacteriophages, suggest how bacteriophage infections may lead to a spread of antibiotic resistance between bacterial populations.

1 During generalised / specialised transduction, host/bacteria DNA can be incorporated into the phage capsid randomly (for generalised transduction)/ adjacent to prophage (for specialised) during viral assembly;

2 The resulting transducing phages infect other bacteria and newly infected cell acquires the donor bacterial DNA

3 Homologous recombination occurs and expression of antibiotic resistance genes result in phenotype of antibiotic resistance

[3]

The practice of using bacteriophages to treat bacterial infections has been around for almost a century but it was brought to a standstill after the successful introduction of antibiotics. The universal decline in the effectiveness of antibiotics has generated renewed interest in this century old practice.

(c) A bacteriophage such as a lambda phage can infect an E. coli cell but not a eukaryotic cell.

Describe how the entry of a bacteriophage into an E. coli cell differs from that of an animal virus such as HIV.

Tail fibres to specific receptors on outer surface of cell wall vs gp120 to specific receptors/ CCR5/ CD4+ receptors on (T) cell surface membrane;

Or

Injects DNA through specific pores in the cell surface; (@ tail sheath contracts) vs fusion of viral envelope with cell surface membrane;

[2]

The replication cycle of the lambda phage in an E. coli cell occurs in two phases, as a prophage or lytically. **Fig. 3.3** shows that these two phases are controlled by the regulatory proteins **cI** and **Cro**, which are encoded by the virus.

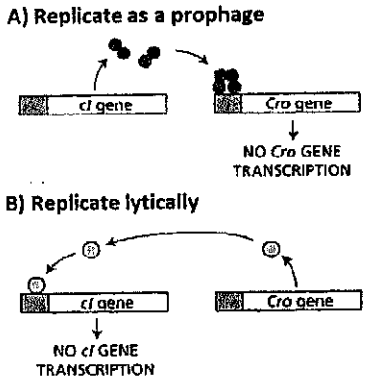

Fig. 5

When bacteria containing a lambda prophage are irradiated with ultraviolet light, the **cI** protein is degraded.

(d) With reference to **Fig. 5**, and your knowledge of bacteriophages, describe the events that occur when the bacteria is irradiated.

induction into the lytic cycle;
cro gene expressed forming CRO protein, transcription of cI gene prevented/ inhibited;
prophage excised;
synthesis and assembly of viral components;
release of new phages;

[3]
[Total: 10]

6 The cells in **Fig. 6.1** are from the same organism and look the same.
The cells in **Fig. 6.1(a)** have been produced by mitosis and the cells in **Fig. 6.1(b)** have been produced by meiosis.

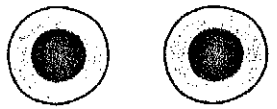

Fig. 6.1(a)

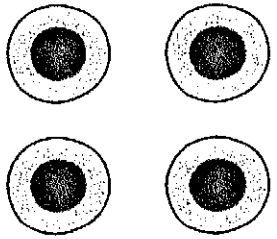

Fig. 6.1(b)

(a) Complete the table to show three differences between cells that have been produced by mitosis compared to cells that have been produced by meiosis.

Mitosis	meiosis
diploid / two chromosome sets / 2n	haploid / one chromosome set /n
same number of chromosomes as parent / AW	half the number of chromosomes as parent / AW
two, copies / alleles / forms, of each	one, copy / allele / form, of each
(cells) genetically identical (to, each @ (cells have) same / AW, DNA / @ no genetic variation	(cells) genetically different @ (cells have) different / AW, DNA / genetic material @ genetic variation

[3]

(b) Fig. 6.2 shows the life cycle of a species of brown seaweed.

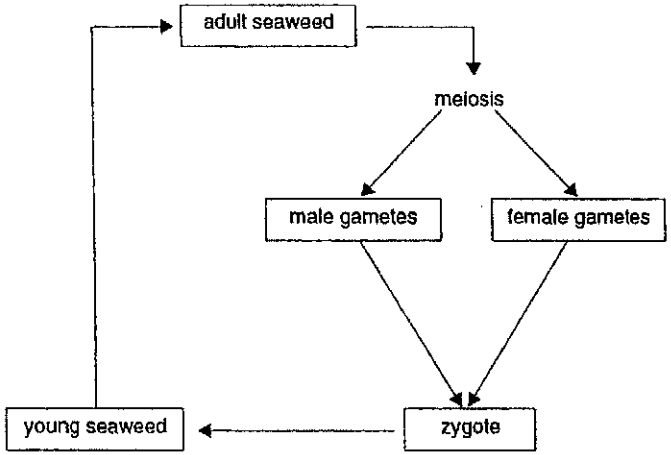

Fig. 6.2

(i) Indicate on Fig. 6.2, with the letter **M**, the stage (s) where mitosis occurs.

M between zygote and young seaweed + between young seaweed and adult;

[1]

(ii) DNA replication occurs in cells during interphase before they divide by mitosis. Explain why it is important that replication occurs before mitosis.

Each chromosomes contains two genetically identical sister chromatids;

Daughter cells receive the same number and same type of chromosomes and are genetically identical to the parent;

[2]

(iii) Explain why meiosis occurs in the life cycle of this seaweed.

Reduction division to produce gametes / sex cells / eggs and sperms with half the chromosome number / haploid / n.

For fertilisation / fusion of gametes to form zygote with diploid / has full number of chromosomes / 2n @ restores diploid number

Chromosome number remains the same / does not increase with each generation when gametes fuse / prevent doubling of chromosome number

ref. genetic variation, linked to evolution / natural selection;

[3]

[Total: 9]

7 In the sweet pea plant, *Lathyrus odoratus*, one gene codes for flower colour and one gene codes for pollen grain shape.

Flower colour is either purple or red. Pollen grain shape is either long or round.
The inheritance of these genes is an example of **autosomal linkage**.

- The allele **F** for purple flowers is dominant over the allele **f** for red flowers.
- The allele **G** for long pollen grains is dominant over allele **g** for round pollen grains.

(a) Explain the meaning of the term *autosomal linkage*.

(autosomal) not a sex chromosome ;

(linkage) genes on the same chromosome / alleles inherited together ;

[2]

(b) A dihybrid cross was carried out between homozygous dominant and homozygous recessive sweet pea plant parents to produce the F1 generation.

The offspring from the F1 generation were crossed to produce the F2 generation.

(i) Draw a genetic diagram to show a dihybrid cross between two offspring from the F1 generation. Assume that these genes are closely linked and that there are no crossing over events.

Correct gametes (FG), (fg);
Correct genotypes FFGG, FfGg, FfGg, ffgg;
Correct phenotypes 3 purple long : 1 red round;

[3]

(ii) The actual results of the dihybrid cross are shown in **Table 7.1**.

Table 7.1

phenotypes of F2 offspring	number of individuals
purple flowers, long pollen grains	284
purple flowers, round pollen grains	21
red flowers, long pollen grains	21
red flowers, round pollen grains	55

State how the results support the fact that this is an example of autosomal linkage.

any 1 of:

do not show 9:3:3:1 ratio ;

large(r) numbers of parental phenotypes / low(er) numbers of recombinant phenotypes ;

[1]

(c) (i) In a test cross, an individual of **known** genotype is crossed with an individual that has a dominant phenotype but unknown genotype.

State the genotype of the **known** individual in a test cross.

fgfg / homozygous recessive ; A ffgg

[1]

(ii) A test cross was carried out with sweet pea plants known to be heterozygous for both flower colour and pollen grain shape. The results of the test cross are shown in **Table 7.2**.

Table 7.2

phenotypes of offspring of test cross	number of individuals
purple flowers, long pollen grains	215
purple flowers, round pollen grains	30
red flowers, long pollen grains	32
red flowers, round pollen grains	210

The result of a test cross can be used to determine a crossover value (COV).
A crossover value is the percentage of the total number of offspring showing recombination.
The crossover value (COV) can be calculated using the formula shown below.

$$\text{COV} = \frac{\text{number of recombinants}}{\text{total number of individuals}} \times 100$$

Calculate the COV from the results shown in **Table 7.2**.
Working ; 12.7 or 13 ;

COV = ... %

[2]

(iii) Suggest what information about the relative distance between the linked genes can be gained from crossover values.

low, COV / crossover value, indicates genes closer together
or high, COV / crossover value, indicates genes further apart ;

[1]
[Total: 10]

8 Maize, *Zea mays*, is a cereal crop that is adapted for growth at high temperatures. However, it does not cope well with drought.
An investigation was carried out into the effect of low water availability on the activity of mitochondria taken from maize seedlings.

Young seedlings were uprooted and left in dry air for varying periods of time to reduce the water potential of their tissues.

(a) After drying in air, mitochondria were extracted from the tissues of the seedlings. The extracted mitochondria were provided with succinate, which is one of the intermediate compounds in the Krebs cycle, and also with ADP and inorganic phosphate. The rate at which the extracted mitochondria took up oxygen was measured. The results are shown in **Fig. 8.1**.

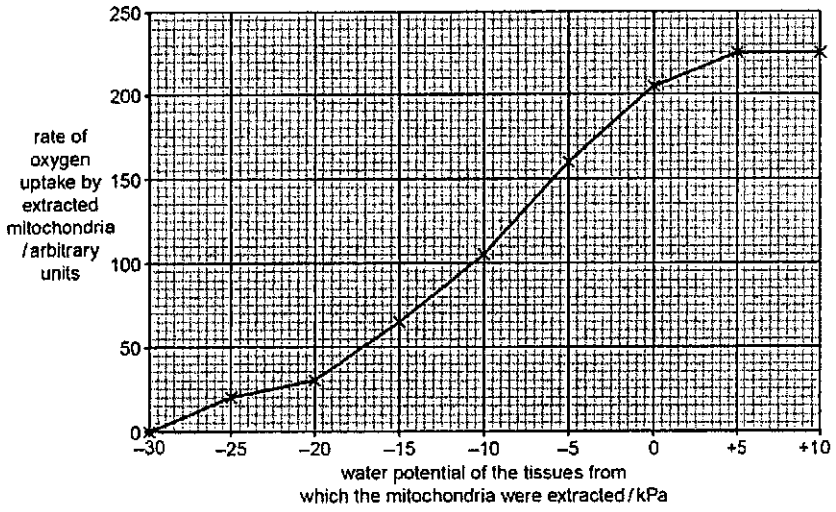

Fig. 8.1

(i) Describe the results shown in **Fig. 8.1**.

as water potential increases, oxygen uptake increases ; (must be stated)

levels off (at 5 kPa / at 225 au) ;

figures ; two water potential + two oxygen uptake figures + kPa

[2]

(ii) The mitochondrion take up oxygen. Explain how this oxygen, plus the succinate, ADP and inorganic phosphate, are used by the mitochondria.

1 succinate converted to oxaloacetate via dehydrogenation / oxidation ;
2 NAD, is reduced / accepts hydrogen ;
3 (proton and electrons move to) ETC ;
4 ADP + Pi synthesize ATP ;
5 oxygen receives protons and electrons / is final electron acceptor, to form water ;

[3]

(b) A mitochondrion contains DNA and ribosomes and is the organelle in which aerobic respiration takes place.
Suggest the functions of the DNA and ribosomes in a mitochondrion.

(DNA for) transcription/ codes for mRNA;

(ribosomes for) translation;

ref to cytochrome oxidase/ electron carriers/ ATP synthase;

[2]

(c) Some parasitic worms, such as tapeworms, live in a mammalian gut where there is no oxygen.
Suggest how a tapeworm produces ATP in this environment.

Anaerobic respiration;

2 net gain of ATP via substrate level phosphorylation (in glycolysis);

Pyruvate is reduced forming lactate/ lactate fermentation;

regenerating oxidised NAD, allowing glycolysis to continue;

[3]

[Total: 10]

9 The Hawaiian Islands are some of the most isolated volcanic islands in the world. It is made up of a group of islands that are formed at different times. The first birds to have flown to these islands probably arrived millions of years ago from East Asia.

Fig. 9.1 and **Fig. 9.2** show the fossils of two extinct species of goose found on two different Hawaiian islands. The Giant Hawaiian goose was a flightless bird whereas the Woodwalking goose could fly.

Until recently, the evolutionary relationships among Hawaiian goose are known only from bone structures. **Fig. 9.1** shows the skulls and beaks while **Fig. 9.2** shows the wing and leg bones of the giant Hawaiian goose and woodwalking goose.

Giant Hawaiian goose Woodwalking goose

Fig. 9.1

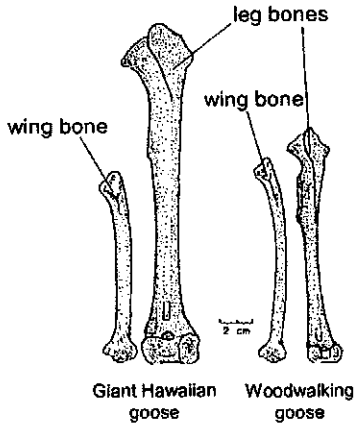

Fig. 9.2

(a) With reference to **Fig. 9.1** and **Fig. 9.2**,

(i) discuss whether the fossil records support Darwin's theory of evolution.

Supports

Same basic structure of skulls and beaks, wing and leg bones indicate shared ancestry / derived from common ancestor ;

Does not support

No common ancestor;

Leg bones of giant Hawaii goose is much longer and stouter (idea of) than woodwalking goose OR

Skull and beak show significant differences in size

Lack of an 'ancestral' fossil for comparison, so difficult to determine if the 2 sets of bones are "modified" from a common ancestral prototype ;

[2]

(ii) explain how natural selection could have brought about the evolution of the leg bone of the giant flightless Hawaiian goose.

Spontaneous / random mutations result in the formation of new alleles ;

Giving rise to heritable variation in the leg bone structure of the goose ;

Goose with longer legs more suited for land-bound type of locomotion / flightless are at a selective advantage as they are more able to run away from predators faster / chase after prey faster ;

Survive and reproduce, pass on beneficial alleles to their offspring ;

Increasing allelic frequency of long leg bone;

[4]

Several fossil specimens of both Hawaiian goose species were found and the mean lengths of their skulls, beaks and wing and leg bones were measured. A statistical test was carried out to determine whether there was a significant difference between these means.

(b) (i) State the statistical test that was carried out.

t-test;

[1]

(ii) A summary of the results is shown in **Table 9**.

Table 9

mean length of skull / mm		significance of difference
giant Hawaiian goose	woodwalking goose	
89.0	31.2	$p < 0.05$
mean length of beak / mm		significance of difference
giant Hawaiian goose	woodwalking goose	
38.6	18.3	$p < 0.05$
mean length of wing bone / cm		significance of difference
giant Hawaiian goose	woodwalking goose	
7.3	8.2	$p > 0.05$
mean length of leg bone / cm		significance of difference
giant Hawaiian goose	woodwalking goose	
14.6	9.4	$p < 0.05$

Comment on what these results show and suggest explanation for any pattern.

Mean length of skull, beak and leg bone of giant Hawaiian goose is higher than that of woodwalking goose / ORA and the difference is significant ;

However, mean length of wing bone of giant Hawaiian goose is not significantly different from that of woodwalking goose ;

(explanation of significance / insignificance) idea that difference in means would occur by less than / more than 1 in 20 / 5%/ 0.05 ;

Differences in mean length of skull, beak and leg bone of both birds are significant, showing that these structures have modified by natural selection to adapt to the selection pressures in their respective islands ;

Differences in mean length of wing bones are not significant, so inconclusive about modification to adapt to different selective pressures for locomotion (i.e. flight vs flightless) ;

[4]

[Total: 11]

10 Human Immunodeficiency Virus (HIV) infects cells of the immune system, particularly helper T-lymphocytes and memory T-lymphocytes. The onset of disease, which can occur many years later, coincides with a severely lowered primary and secondary immune response, owing to greatly reduced numbers of helper T-lymphocytes in the body.

(a) Explain how the destruction of memory T-lymphocytes will contribute to a lowered **secondary** immune response.

[3]

Less cytokines released;

Unable to simulate humoral / B cell response;

Poor antibody production / no antibody secreted;

No memory cells in circulation for second encounter with antigen;

(b) Tuberculosis (TB) is an important disease worldwide.

Suggest why TB is more likely to be fatal in people who have HIV/AIDS than in those who do not have HIV/AIDS.

(HIV/AIDS leads to) weak immune system/reduced immunity (to disease) ;

detail ; e.g. reduced action of phagocytes

T_h lymphocytes low in number

B-lymphocyte response low

(so TB) pathogens, can multiply faster/ are not destroyed before they cause disease ;

idea that important, organs / systems, may already be suffering from consequences of HIV/AIDS (so more likely to stop functioning) ;

ref. to, inactive/dormant/ latent, TB more likely to become active ;

[2]

[Total: 5]

11 Plants have long been regarded as carbon sinks because they take in carbon dioxide for photosynthesis. However, when temperatures rise, plants increase their rate of respiration, resulting in increased carbon dioxide release. Some research has suggested that this could convert forests from a long-term carbon sink to a carbon source, aggravating climate change.

In 2016, a team of scientists conducted a short-term study of five years to find out the net carbon exchange of trees when the temperature was increased. In order to determine this, the increase in leaf respiration at higher temperatures was evaluated using 1000 young trees of 20 different boreal and temperate tree species grown in an open-setting.

Fig. 11 showed the observed and expected data that had been derived from mathematical model projection using computer simulation.

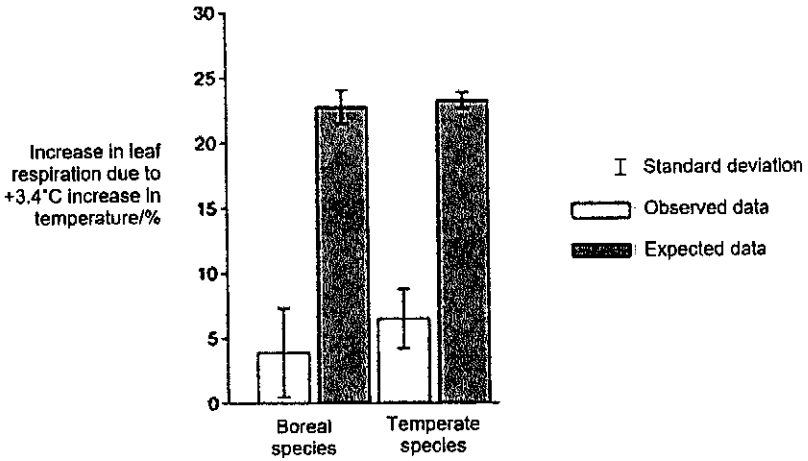

Fig. 11

(a) With reference to **Fig. 11**, describe one difference between the observed and expected data.

1. For both types of trees, the expected increase in leaf respiration was higher than that of the data observed;

2. The expected increase in leaf respiration was 23 and (22.5 to) 24% while that observed showed an increase in (3.5 to) 4% and (6.5 to) 7% respectively for boreal and temperate species;

OR

3. For both types of trees, the standard deviation for expected results was smaller than that for the data observed;

4. The standard deviation for expected data was (3 to) 4% and (1 to) 2% respectively for boreal and temperate species compared to 7 (to 8%) and 5% for the data collected;

[2]

(b) In **Fig. 11**, the observed data shows a difference in the increase in leaf respiration between boreal and temperate tree species. Suggest why this difference is not significant.

The difference is not significant as the standard deviation bars overlaps;

[1]

(c) Based on the results of the study, comment on whether forests will remain as carbon sinks or be converted to carbon sources if temperatures rise.

1. The rate of plant respiration did not increase as much as expected, suggesting that the rate of photosynthesis may still be higher than the rate of respiration;
2. Overall, plants will take in more carbon dioxide than it gives out / remain as carbon sinks;

OR

3. The rate of plant respiration did not increase as much as expected. However, there is still an increase in respiration which may result in the rate of respiration becoming higher than the rate of photosynthesis;
4. Plants might become carbon sources instead of carbon sinks;

[2]

[Total: 5]

BP~195

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME **ANSWERS**

CLASS

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

September 2019

Additional Materials: Answer Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer all questions in the spaces provided on the Question Paper

Section B

Answer any one question on the separate Answer Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
Total	

This document consists of 13 printed pages and 1 blank page.

[Turn over

Section A

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

1 In Africa, *Anopheles gambiae* is one of the best-known mosquito vector species because of its role in the transmission of the dangerous malarial parasite – *Plasmodium falciparum*.

Molecular analyses reveal that there are two forms of *A. gambiae*, the **M** and **S** molecular forms. These two forms are morphologically identical but show widespread molecular differences throughout their genomes.

The **M** and **S** molecular forms of *A. gambiae* are found in and around irrigated rice fields located within the same humid savannahs of western Africa. The **M** form is associated with larger permanent breeding sites mostly consisting of rice paddies, whereas the **S** form is found to depend on temporary, rain-filled breeding sites. Although interbreeding between **M** and **S** forms yields fertile progeny, **M-S** hybrids are rarely observed in nature.

(a) (i) Describe how the molecular differences between the **M** and **S** forms of *A. gambiae* could have come about.

Random / spontaneous mutation ;

Due to ultraviolet light / ionising radiation (or any logical reason for how mutation could arise in the mosquito in the wild) ;

[2]

(ii) Suggest how the level of molecular differences between the two forms of *A. gambiae* could have been determined.

Idea of comparing / aligning sequences like DNA / mitochondrial DNA / amino acids / proteins / DNA-DNA hybridization ;

[1]

(iii) One advantage of molecular analyses is the ability to detect evolutionary changes between populations even though they may look morphologically similar or identical.

Other than the advantage stated above, describe **two** advantages of molecular analyses in classifying organisms.

Molecular data is unambiguous and objective and is based strictly on heritable material;

Degree of divergence between different species can be quantitatively measured by comparison of amino acid or nucleotide sequences, which is precise and can be open to statistical analysis;

Morphological evidence can be confounded due to convergence, whereby similarities in morphology is due to analogous structures and not common descent/ some morphological characteristics may be analogous / ref. convergent evolution;

Molecular evidence can detect neutral mutations ~~(for use in molecular clock)~~ to determine divergence in the different species;

@ establishing evolutionary relationships of organisms that reproduce asexually / are extinct as long as DNA material is available

[2]

(b) Explain the type of speciation *A. gambiae* is undergoing.

sympatric speciation ; Reject: allopatric speciation

separated by a behavioural barrier in reproduction e.g. different mating behaviours / description ; Reject: geographical or physiological isolation / barriers

Speciation has occurred when there is reproductive isolation / no interbreeding between the M and S / no gene flow (between the two forms) even though both are found very close to each other / within the same geographical location ; Reject reduced gene flow

[3]

(c) *A. gambiae* go through four stages in its life cycle.

Complete **Fig. 1.1** to show these stages.

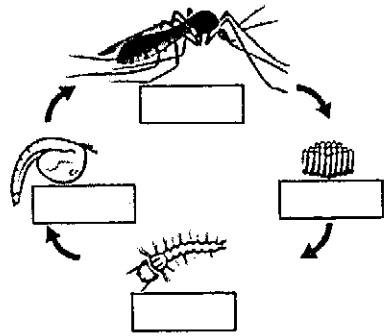

Fig. 1.1

Egg, larvae, pupae and adult; R mosquito for adult

[1]

(d) *Anopheles* mosquitoes thrive in regions with warm temperatures, humid conditions, and high rainfall. Thus, tropical and subtropical areas are ideal. Warm temperatures are also required for malarial parasites to complete their growth cycle within the mosquitoes.

Climate change due to global warming is expected to cause latitudinal and altitudinal temperature increases. Such a temperature increase will alter the biology and ecology of many mosquito vectors and subsequently, the dynamics of the diseases they transmit.

(i) Explain how increased temperatures could impact the biology of insects like mosquitoes.

Compulsory point: Idea of increased ambient temperatures lead to increased body temperatures of insects, resulting in increased metabolism ;

shorter / faster life cycles / lay more eggs / higher egg laying rate;

Female mosquitoes able to stay active for longer period e.g. of activity (feeding, mating)

Idea of narrower temperature tolerance – mosquitoes may not survive / have developmental problems when temperatures go too high (beyond the maximum temp they can tolerate) ;

[2]

(ii) Globally, average temperatures could increase by more than 2°C by the end of the 21st century.

Suggest **and** explain the effect this change in temperature will have on the distribution of malaria across the world.

Idea of spread beyond the tropics / malaria cases appearing in temperate areas / poleward expansion / at higher or lower latitudes / higher altitudes ;

Explain that spread of Malaria will increase due to mosquitoes being able to thrive in areas where it was previously unsuitable for its breeding;

A Warmer temperatures means increased precipitation → breeding sites for *Anopheles* mosquitoes ;

[2]

A research team investigated the activity of two forms of catalase, P and Q, extracted from *A. gambiae*. The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism, into oxygen and water. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.

The results are shown in **Fig. 1.2.**

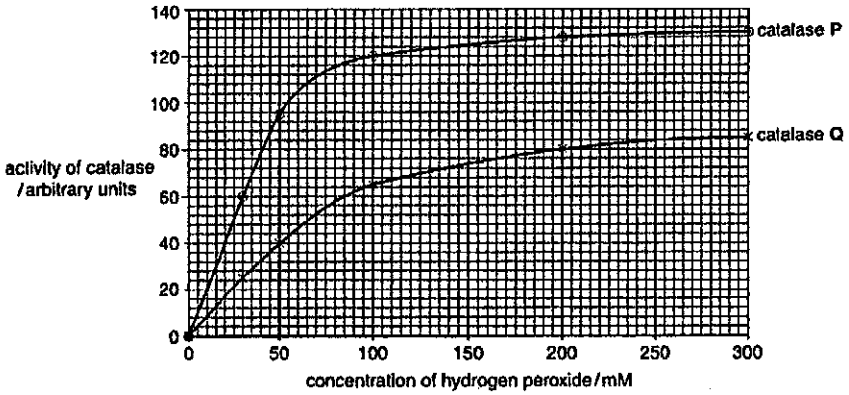

Fig. 1.2

(e) With reference to **Fig. 1.2, describe and explain** the effect of increasing the concentration of hydrogen peroxide on the activity of catalase **P**.

Describe (2m):

1 activity /rate, increases linearly then plateaus off ; A 'levels off'/remains constant/reaches Vmax
2 data quote with units to support any correct statement ; e.g. 128–132 arbitrary units at 250–300mM, 0 to 120 arbitrary units between 0 and 100mM, 120–128 arbitrary units between 100 and 200mM R abbreviation (a.u.)

Explain (2m):

at low/ increasing, concentration of hydrogen peroxide

3 substrate/hydrogen peroxide, (concentration) is limiting (factor) ;
4 active sites, unoccupied (low concentration)/ become more occupied (increasing concentration) ;
5 (low concentration) few effective collisions between enzyme and substrate/few E-S complex formed per unit time / low rate of E-S complex formation
OR
(increasing concentration) more effective collisions between enzyme and substrate/ higher number of E-S complex formed per unit time / high rate of E-S complex formatioon ;

At higher concentration of hydrogen peroxide (plateauing off)

6 enzyme/ catalase, concentration/AW, becomes / is, limiting (factor) ;
7 maximum number of enzyme-substrate complexes formed per unit time / maximum rate of E-S complex formation ;
8 (all) active sites, saturated/(always) occupied ; A ora

[4]

(f) Each molecule of catalase consists of four identical polypeptides. The two forms of catalase in *A. gambiae* differ by only one amino acid at position 2 in the amino acid sequence. Catalase **P** has serine and catalase **Q** has tryptophan.

Suggest how the difference in one amino acid is responsible for the lower activity of catalase **Q** compared with catalase **P**.

amino acid at position 2, is part of active site/ helps to give shape to active site/ helps form the structure of the active site ;

idea of different, R group/ side chain, gives different properties, resulting in different interactions / bonds;

(tryptophan has a, hydrophobic R group/ serine has a polar R group)

(slightly) different, folding of polypeptide/ secondary structure/ tertiary structure / quaternary structure / 3-dimensional conformation;

Idea that active site of P better fits / more complementary / binds better to substrate than that of Q;

[2]

(g) Blood is a rice source of proteins for mosquitoes. Female mosquitoes feed on blood in order to produce their eggs. After feeding, the metabolic rate increases for egg production.

(i) The researchers allowed female mosquitoes to feed on blood. They found that female mosquitoes with only catalase **P** produced more eggs than those with only catalase **Q**.

Suggest why there is a difference in egg production between the two types of *A. gambiae*.

1 increased, metabolic rate/protein metabolism (after feeding) means, increased/ more, hydrogen peroxide (produced) ;
2 idea that less effective, catalase/Q, means, more hydrogen peroxide remains / less hydrogen peroxide broken down ;
3 hydrogen peroxide, interferes with/ is damaging to/AW, egg production ;

Ignore ref. to oxygen production and use in aerobic respiration

[2]

(ii) The proteins in blood are broken down into amino acids and absorbed by the epithelial cells in the mosquitoes' midgut. Amino acids require specific carrier proteins to enter cells.

Explain why carrier proteins are required in cell surface membranes for the transport of amino acids.

needed for, facilitated diffusion/ active transport ;
A description of active transport e.g. moving, molecules / ions, against a concentration gradient
ref. to amino acids being charged ;
Therefore repelled by hydrophobic core of phospholipid bilayer;
I large cannot pass through, phospholipid bilayer/ hydrophobic core ;

[2]

(h) Other than the transport of substances into and out of cells, describe **two** roles of cell surface membranes.

1.

2.

1 barrier between cell cytoplasm and, external environment/AW ; e.g. tissue fluid
R barrier unqualified
R 'keeps cell contents in'
R 'membrane surrounds the organelles'
R barrier for water soluble substances
2 receptor to bind to signal molecule / hormone for cell signalling ;
3 glycoproteins and glycolipids for cell recognition / cell-to-cell adhesion ;
5 site for, enzymes / catalysing reactions ;
6 anchoring the cytoskeleton/AW ;
7 formation of hydrogen bonds with water for stability ;
8 AVP ; e.g. ref. to, changing shape of cell/ flexibility of cells e.g. phagocytosis
R compartmentalisation

[2]

[Total: 25]

2 The coat colour of Norwegian cattle is mainly determined by the distribution of two pigments: red and black. Both pigments are produced by the action of the enzyme tyrosinase in cells called melanocytes. A low level of activity of the enzyme leads to the production of red pigment, whilst a high activity allows only black pigment production. The activity of the enzyme is increased by melanocyte stimulating hormone (MSH), which combines with an MSH receptor. The receptor is coded for by the **E** locus, which has three alleles, E^D, E^A and **e**. E^D and E^A each give a receptor with a different activity. No receptor is produced by the recessive allele, **e**.

The dominant allele of a second gene, the **A** locus, codes for a protein which binds to and blocks the MSH receptors coded for by E^A, thus preventing stimulation of tyrosinase activity in melanocyte. The receptor coded for E^D is insensitive to the protein coded for at the **A** locus.

The effects of the different alleles of the two loci are summarised in **Table 2.1**.

Table 2.1

E locus	
genotype	*MSH receptor*
E^DE^D or E^De	insensitive to A locus blocking protein
E^AE^A or E^Ae	Sensitive to A locus blocking protein
ee	none

A locus	
genotype	*Protein which blocks MSH receptor*
AA or Aa	present
aa	absent

(a) **(i)** State the name given to interaction between gene loci, such as that between the **E** and **A** loci.

Epistasis ; *Ignore mention of specific types of epistatsis*

[1]

(ii) Explain why animals with the genotype **E^AE^AAA** have red coats.

E^AE^A codes for MSH receptors ;

AA codes for proteins that block MSH receptors ; Rej: inhibitors alone

[2]

(iii) Predict the coat colours of animals with the following genotypes:

eeaa red ;
E^Aeaa Black ;
E^DeAa black ;

[3]

Allele E^A differs from E^D by a single base substitution and **e** differs from E^A by a single base deletion.

(b) Suggest how these mutations might result in differences in the MSH receptor.

1. codon changed, amino acid changed / is different ;

2. (bonds between R groups changed) thus 3D conformation / shape / tertiary structure changed, altering binding ability/ binding site of MSH receptor to A protein ;

@ no longer able to bind to A protein ; *Ignore ref to premature termination of translation / truncated protein*

Rej: receptor site / active site

[2]

DNA was extracted from the frozen semen of six bulls with different genotypes at the E locus. The DNA from each animal was separately digested with two different restriction enzymes **P** and **Q**. The products of each digestion were separated on a gel. The banding patterns produced with respect to this locus are shown in **Fig. 2.1**.

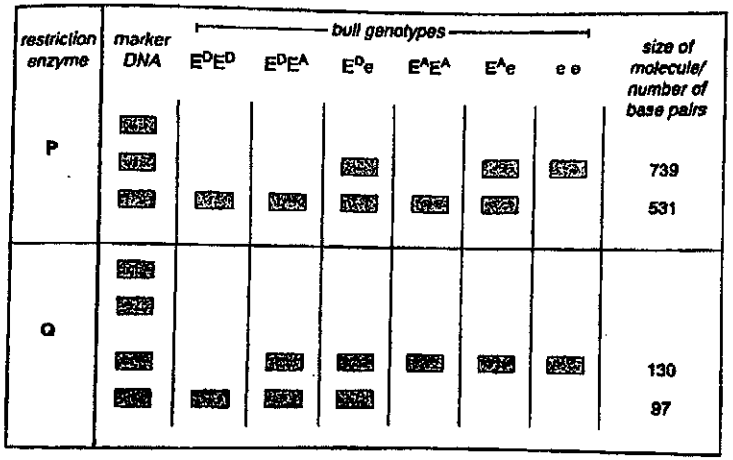

Fig. 2.1

(c) Explain briefly how the products of digestion of DNA with restriction enzymes can be separated on a gel.

Direct current used to move negatively charged DNA / sugar phosphate backbone from the negative electrode / terminal to the positive electrode / terminal Rej: pole / end / side ; Rej: DNA strands / alleles Avoid writing cathode and anode!

Larger / longer fragments move faster / longer distances through the gel compared to the smaller / shorter fragments ;

[2]

(d) Suggest why the products of digestion of DNA from the same animal are different when a different restriction enzyme is used.

ref to enzyme specificity in terms of active site/ different RE recognise / binds to specific restriction site / nucleotide / base / DNA sequences ;

Rej: genes / nucleotides alone / bonds between nucleotides as substrates

active site of enzyme complementary to sequence of DNA in terms of shape / conformation ;

[2]

(e) State which genotypes can be identified by using each of the two restriction enzymes.

P ee ;

Q E^DE^D ;

[2]

[Total: 14]

3 B-lymphocytes respond to the presence of an antigen by dividing as shown in **Fig. 3.1**.

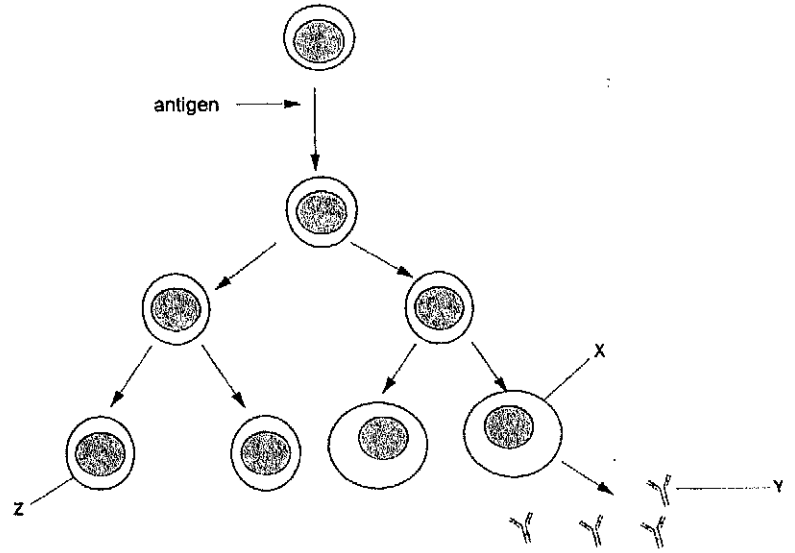

Fig. 3.1

(a) Describe how **Y** are released from cell **X**.

Compulsory point: vesicles move to cell/ surface/plasma, membrane (via cytoskeleton) ; R secreting vesicles unqualified

vesicles fuse with cell (surface) membrane/exocytosis ; R active transport

movement of vesicle/ exocytosis requires energy or ATP/ is active process;

[2]

Cell **Z** has an important role in the immune system.

(b) Explain the role of cell **Z**.

memory cells ; @ form immunological *memory Ignore 'gives immunity' remain/ stay in circulation/ blood/lymphatic system* ; R 'last a long time/ long lived' unqualified

During secondary response, faster response when exposed again to same pathogen/ same antigen ; @ faster clonal selection/ faster clonal expansion @ divide quickly /rapidly @ longer lasting response

to form plasma cells so that more antibodies produced/higher concentration of antibodies ; R if in context of memory cells

to prevent person feeling ill/ to prevent symptoms ;

[3]

Fig. 3.2 shows the sequence of events in one the cell signalling pathways when a B-lymphocyte encounters an antigen.

LYN and **SYK** are tyrosine kinases.

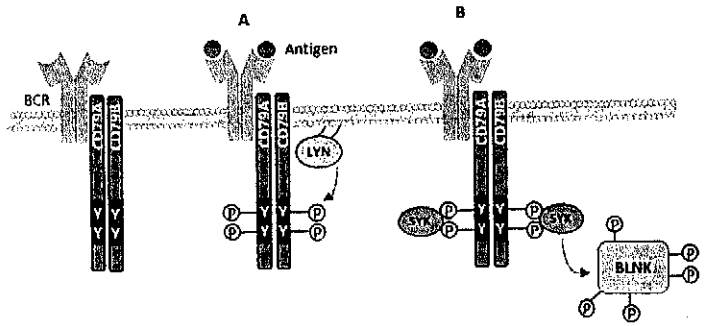

Fig. 3.2

(c) With reference to the main stages of cell signalling and **Fig. 3.2**,

(i) describe stages **A** and **B**.

A During ligand-receptor interaction, antigen binds to specific B cell receptor ® BCR found on cell surface membrane.

B cell receptor is associated with membrane protein CD79A and CD79B

Phosphorylation of Tyr residues on CD79A and CD79B by LYN

B During signal transduction, activated receptor recruits SYK

SYK phosphorylate tyrosine residues on BLNK ® activates

[4]

(ii) suggest how can the signal be terminated.

role of phosphatases: remove phosphate from CD79A and CD79B or remove phosphate group from BLNK

signal transduction cannot occur

@ dissociation of antigen/ receptors removed via endocytosis (only max 1m)

Only 1m award if students state that dephosphorylation is a result of the antigen dissociating from receptor.

[2]

[Total: 11]

Section B

Answer **one** question in this section.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

4(a) Discuss why life would be impossible without ATP. [13]

Structure & Properties of ATP (SP max 4)

1. ATP consists of a ribose sugar, an adenine base and 3 phosphate groups.
2. ATP is universal energy carrier / energy currency in living organisms
3. ATP is easily hydrolysed to ADP and inorganic phosphate (Pi) to release energy
4. Other properties of ATP; e.g. ADP is easily phosphorylated with inorganic phosphate (Pi) to form ATP catalysed by ATP synthase / soluble + idea of use within the cell;
5. ATP is synthesised from oxidation of glucose / OP / SLP via cellular respiration;
6. ATP is produced in the light dependent reaction via photophosphorylation;

Chemical processes that require ATP [C- max 8];

1 (a) Hydrolysis of ATP is required for reduction of glycerate-3-phosphate to glyceraldehyde-3-phosphate / carbon reduction and regeneration of RuBP during light independent reaction / Calvin Cycle;

1 (b) Allows the continuation of carbon fixation / Calvin cycle to produce carbohydrates / glucose in photosynthesis

2 (a) ref to glycolysis in respiration requires ATP for phosphorylation of glucose / activation of glucose.

3 (a) ATP is required as an energy source for DNA replication in unwinding and unzipping of DNA helix to separate the parental strands by DNA helicase

3 (b) Ref to energy required to break hydrogen bonds between two DNA strands so that they can each act as templates for replication;

4 (a) ATP is required as an energy source for amino acid activation during translation; ® translocation of ribosome

4 (b) Allows for the covalent attachment of an amino acid to the 3' acceptor stem of the corresponding tRNA

5 ATP is a ribonucleotide; one of the monomers in RNA synthesis during transcription;

6 (a) ATP provides the energy for active transport ® active transport of substances across cell membranes against the concentration gradient;

6 (b) Energy is required for the conformational change of carrier ® channel proteins to pump substances. E.g. proton pumps ensure the low pH in lysosomes to ensure optimum condition for the hydrolytic enzymes

7 (a) ATP provides the energy for bulk transport such as endocytosis and exocytosis;

7 (b) E.g. Allows for the secretion of proteins such as insulin hormone for (homeostasis) / phagocytosis of pathogen by phagocytes (for immunity) / secretion of antibodies by plasma cells;

8 (a) ATP is used as a substrate for adenylate cyclase to be converted into cAMP / to phosphorylate receptor tyrosine kinase by autophosphorylation / phosphorylate kinases in phosphorylation cascade in cell signalling;

8 (b) Ref to important in signal transduction resulting in a cellular response;

9 Ref ATP is required for synthesis of organelle

10 Ref to ATP is required for muscle contraction to allow for movement of the animals;

11 (a) Ref to movement processes within a cell e.g. movement of chromosomes / movement of vesicles

11 (b) Movement is aided by rearrangement of cytoskeleton / microtubules

12 Ref to phosphorylation of protein to activate it in post translational modification

AVP Sperm movement

AVP in prokaryotes, ATP is converted to cAMP; binds to catabolite activator protein to increase rate of transcription;

Importance of ATP to life [L - max 4]

1 (ref to photosynthesis) Carbohydrates (glucose) important for in ensuring the growth of plants / Ref to plants as producers - food for other organisms;

2 (ref to muscle contraction) important for **locomotion** / allow them to find / catch food / escape from predators / harm or to migrate to cope with environmental changes;

3 (ref to mitosis and meiosis) ensure that organisms would be able to grow ® cell growth / tissue repair / (sexual or asexual) reproduction ;

4 (ref to proteins) important for metabolic reactions

5 (ref to antibodies / phagocytosis) important for immunity

6 (ref to hormones / cell signalling of glucagon or insulin) important for homeostasis;

7 (ref to transport across membrane) is important for obtaining nutrition / excretion of waste products.

8 Ref to cell signalling important for communication / coordination / response to changes;

(b) Describe the effects of different types of mutations on the proteins of eukaryotes. [12]

Types of mutations (M)

1. (Gene) Mutation is a change in nucleotide sequence in the DNA ;
2. Substitution mutation is the replacement of one nucleotide pair with another pair ;
3. Deletion mutation is removal of one nucleotide/ bp removed ;
   Addition mutation is insertion of one nucleotide/ bp ;
4. Chromosomal aberration is a change in the structure ® type of a chromosome, or the number of chromosomes of an organism.
5. Ref to aneuploidy + possess an extra chromosome or lack of chromosome due to non-disjunction during meiosis;
6. Ref to deletion / duplication / inversion / translocation of chromosomal fragment chromosomal duplication + detached chromosomal fragment from a sister chromatid become attached as an extra fragment to another sister chromatid

(mutations in non-coding regions)

7. introns are non-coding DNA seq + removed / excised during post transcription modification / splicing ;
8. ref promoter / silencer / enhancer are non-coding DNA seq + role;

Effects (E)

1. Ref to mutation result in a change in mRNA sequence / mRNA codon ;
   (a) Change in codon in mRNA to a premature stop codon ;
   (b) Change in codon in mRNA + change in amino acid with a R group of different chemical property @ sickle cell anaemia e.g. of hydrophilic glutamate changed to hydrophobic valine
2. Same amino acid + degeneracy of genetic code / a few mRNA codons code for the same amino acid ;
3. (ref to addition / deletion) frameshift mutation / alteration of reading frame leading to extensive change in amino acid sequence;
4. (a) Ref to stop codon result in termination of translation + polypeptides is shorter than original
   (c) (same aa) Ref to same primary structure and fold in the same way to form same three-dimensional conformation;
   (d) (different aa) Ref to change in R group interaction result in a change in three-dimensional conformation and tertiary structure;
5. Ref to location of mutation with specific example (active site of an enzyme ® protein);

N1 (ref to mutation in non-coding regions) ref to how transcription is increased / decreased ;
N2 resulting in more proteins / less proteins being synthesised (quantity);
AVP mutations in non-coding + non-regulatory sequences (centromeres / telomeres) result in no change in protein function and quantity of protein produced;

QWC: 1 coding +1 non-coding ;

[Total: 25]

3(a) Discuss why intracellular enzymes are essential to **life**. [13]

Enzyme structure and function [S - 4 max]

1. Enzymes have unique/ specific three-dimensional conformation with an active site, which is formed by 3 to 12 amino acids from different parts of a single polypeptide chain;
2. The active site of an enzyme is complementary to its substrate in terms of shape, size, charge and orientation determining the enzyme specificity;
3. When substrate binds to the active site of enzyme with weak bonds such as hydrogen bonds / ionic bonds / hydrophobic interactions, the enzyme-substrate complex (E-S complex) is formed;
4. Effective in small amounts as they remain chemically unchanged at the end of the chemical reaction OR Enzymatic activity are affected by factors such as substrate concentration, enzyme concentration, temperature and pH;
5. Allosterically regulated enzymes are constructed from two or more subunits and their activity are regulated by inhibitors and activators;
6. E.g. Phosphofructokinase is inhibited by ATP and citrate, known as end-product/ feedback inhibition as both of which are products of enzymatic reactions in cellular respiration;

Role of Enzymes in Prokaryotes & Eukaryotes [R - 8 max]

1. (Ref to antibiotic resistance): Bacteria can develop antibiotic resistance by producing enzymes that:
2. E.g. enzymes that degrade antibiotic (penicillinases) / modifies antibiotic such that it loses its activity.
3. (Ref to prokaryotic enzymes): Prokaryotic enzymes that allow some bacteria to live in extreme conditions (e.g. thermal vents/ sulphuric vents)/ chemoautotrophic
4. Taq polymerases are able to catalyse DNA replication at high optimum temperature/ highly thermostable.
5. Role of enzyme in DNA replication to form new/ identical DNA molecules;
6. Ref to enzymes such as DNA helicase, DNA polymerase with correct description of enzyme function;
7. Role of enzyme in transcription which transcribes DNA to produce mRNA for protein synthesis;
8. Ref to RNA polymerase with correct description of enzyme function;

9. Ref to HDACs/ HATs for chromatin modification, affecting the transcription/ gene expression;
10. Role of enzyme in translation to synthesize polypeptide/ protein from mRNA;
11. such as amino acyl tRNA synthetase in amino acid activation/ peptidyl transferase catalysing formation of peptide bonds;
12. Role of enzyme in cell signalling;
13. such as protein kinases in phosphorylation cascade, allowing for signal amplification/ adenyl cyclase to convert ATP to cAMP as second messengers/ tyrosine kinases for autophosphorylation;
14. Role of enzyme in cell division to form new daughter cells in mitosis/ meiosis;
15. such as telomerase in stem cells, (ref to enzymes for microtubule reorganization) spindle formation and cytokinesis;
16. Role of enzyme in respiration synthesising ATP for use by the cell;
17. E.g. ATP synthase to synthesis ATP from ADP + Pi/ cytochrome oxidase in oxidative phosphorylation to form water from oxygen and H+;
18. Role of enzyme in digestion in autolysis/ autophagy;
19. such as hydrolytic enzymes in lysosomes which allow intracellular digestion of foreign organisms during innate immune response / fusion of lysosome with phagosome, etc
20. Role of enzyme in photosynthesis to produce carbohydrates/ sugars;
21. such as ATP synthase in light dependent reaction allow production of ATP for Calvin cycle to produce carbohydrates / Rubisco which allows for carbon dioxide to combine with RuBP during carbon fixation in Calvin cycle / enzyme catalysing photolysis of water;
22. AVP: Role of enzymes in transport of gases, immune response etc

Importance of intracellular enzymes to life [L - 4 max]

1. [enzymes invl in cell division/ replication]: important for ensuring growth in multicellular organism/ reproduction in unicellular organisms;
2. [enzymes invl in muscle contraction]: important for locomotion/ movement/ response, find/ catch food/ escape from predators/ harm/ migrate;

3. [enzymes invl in photosynthesis & respiration]: metabolic reactions in can be carried out in ensuring growth of plants and the supply of food for other organisms/ plants as producers, heterophic nutrition;

4. [enzymes invl in immunity], production (protein synthesis) of antibodies/ hydrolytic enzymes (ref to macrophages), granzymes;

5. [enzymes invl in homeostasis]: (phosphorylases/ kinases) in blood glucose regulation, maintaining a constant internal environment;

6. [enzymes invl in cell signalling]: communication/ coordination;

7. AVP: ref to enzymes in protein synthesis (e.g. peptidyl transferase, amino acyl tRNA synthetase) in making (enzymes) + any of characteristics of life
*only award once for each characteristic of life

(b) Describe how variation arises and how recessive alleles are preserved in a population. [12]

Variation [V - 10 max]

1. gene mutations + change in nucleotide sequence;
2. any one e.g. substitution, deletion or insertion of a nucleotide;
3. chromosomal mutations/aberrations which involve a change in number and/or structure of chromosomes resulting in a change of phenotype of organism;
4. ref to one example (a or b)
    a. (number of chromosomes) non-disjunction (WTTE) resulting in polyploidy/aneuploidy;
    b. (structure) any one with elaboration; e.g. deletion - when a segment of a chromosome is missing/ e.g. duplication - when an extra segment of a chromosome is present/ e.g. inversion - when a chromosome segment is detached, flipped around 180 degrees & reattached to the rest of the chromosome/ e.g translocation - when a segment from one chromosome is detached & reattached to a different chromosome;
5. Meiosis: independent assortment (and segregation) of homologous chromosomes in Metaphase I, when arrangement of one pair of homologues at the metaphase plate is independent of the arrangement of the other pairs of homologues and subsequently separation of homologous chromosomes during anaphase I;
6. results in gametes with numerous combinations of maternal & paternal chromosomes;
7. Meiosis: crossing over between non-sister chromatids during prophase I between non-sister chromatids of homologous chromosomes;
8. results in new combinations of alleles;
9. random fusion/ fertilisation of gametes during sexual reproduction gives rise to a variety of genotypes. Different genotypes will result in different phenotypes (and these will act as raw materials for natural selection);
10. (ref to prokaryotes) idea of homologous recombination to insert DNA from a donor bacteria into the recipient bacteria's chromosome;
11. (description of) transformation: naked, foreign DNA taken up by recipient bacteria;
12. (description of) transduction: phage involved in the transfer of DNA from a donor bacteria to a recipient bacteria;
13. (description of) conjugation: F plasmid transferred from F+ cell to a F- cell via formation of a sex pilus;
14. AVP: Continuous variation due where variation in phenotype/ characteristics (can be due to) interaction of genotypes and environment;

BP~207

H

NANYANG JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME **ANSWERS**

CLASS

BIOLOGY

9744/04

Paper 4 Practical

28 August 2019

Candidates answer on the Question Paper
Additional Materials: As listed in the Confidential Instructions

2 hour 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer all questions in the spaces provided on the Question Paper

Shift
Laboratory

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 no use appropriate units.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
1	
2	
Total	

1 You are provided with a solution, labelled **E**, containing an enzyme which coagulates (clots) milk. Enzyme **E** hydrolyses (breaks) peptide bonds between certain amino acids in a protein found in milk and this results in the coagulation of the milk. Calcium ions are required for this coagulation.

You are required to:

- carry out a trial test to think about sources of error
- make simple (proportional dilutions) of the proteins in the milk, **M**
- record the time taken to reach end point for each of the concentrations of M.

When a mixture of milk, calcium chloride solution and **E** is gently rotated in a test-tube the coagulation goes through the stages shown in Fig. 1.1.

Stage 3 is the end-point of the enzyme-catalysed coagulation.

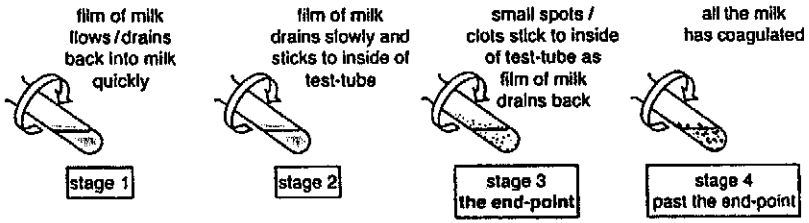

Fig. 1.1

The time taken to reach **end-point** gives an indication of the concentration of protein in milk.

You are provided with:

Table 1.1

labelled	contents	hazards	volume / cm^3
C	10% calcium chloride solution	harmful irritant	20
W	distilled water	none	100
M	milk	none	100
E	1% enzyme solution	harmful irritant	20
U	milk with an unknown concentration of protein	none	20

If **C** or **E** comes into contact with your skin, wash off immediately under cold water. It is recommended that you wear suitable eye protection.

You are required to carry out a trial test (step 1 to step 16) before you start your investigation.

Read step 1 to step 16 before proceeding.

Proceed as follows:

1. You are provided with a beaker labelled **water-bath**. Use the hot and cold water to set up a water-bath in this beaker. The starting temperature of the water-bath should be between 35°C and 40°C.

   You will **not** need to maintain this temperature during steps 2 to 15.

2. Put $10cm^3$ of **M** into a test-tube.

3. Repeat step 2 so that you have three test-tubes containing **M**.

4. Put $1cm^3$ of **C** into each test-tube.

5. Gently shake each of the test-tubes to mix **M** and **C**.

6. Take the temperature of the water-bath and record this temperature in **(a)(ii)** on page 5.

7. Put the test-tubes into the water-bath and leave for at least 3 minutes.

(a) (i) Explain why the test-tubes are left in the water-bath for at least 3 minutes in step 7.

refers to the contents of the test-tubes reaching the temperature of the water-bath ;

.....

.....

[1]

8. Remove one of the test-tubes from the water-bath.

The process of coagulation will start when E is added to the test-tube.

9. Put 1cm^3 of E into the test-tube, so that it runs down the side of the test-tube and forms a layer on the surface of the mixture, as shown in Fig. 1.2.

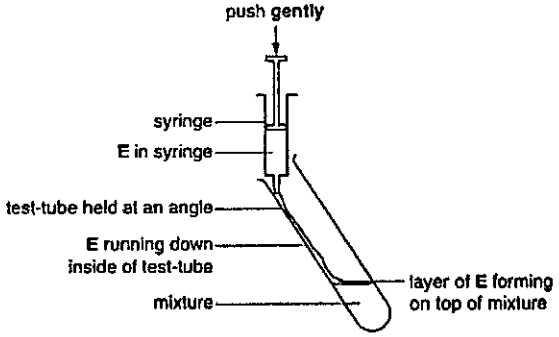

Fig. 1.2

10. Start timing.

11. Hold the test-tube over a piece of black card on the table as shown in Fig. 1.3.

12. Gently rotate the test-tube to form a film of milk on the inside of the test-tube.

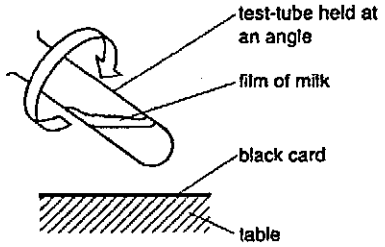

Fig. 1.3

13. Observe the film until the end-point is reached (stage 3 in Fig. 1.1). Ignore any small bubbles on the inside of the test-tube. Stop timing.

14. Record in **(a)(iii)** the time taken to reach the end-point.

    If the end-point has not been reached in 4 minutes, stop the experiment and record 'more than 240'.

15. Repeat step 8 to step 14 with each of the other two test-tubes in the water-bath.

16. Take the temperature of the water-bath when the final test-tube has been removed and record this in **(a)(ii)**.

(ii) Temperature may be a source of error in this investigation.

State the temperatures of the water-bath.

temperature of water-bath taken in step 6 ..... °C

temperature of water-bath taken in step 16 ..... °C

Explain whether the temperature of the water-bath is a significant source of error in this investigation.

appropriate statement concerning temperature as a significant source of error with reference to the difference in temperature at the end of the investigation ;

.....

.....

[1]

(iii) Record your results in an appropriate table.

table drawn + heading, trial or test-tube ;

records 3 times ;

[2]

(iv) A significant source of error for this investigation is deciding when the end-point is reached.

Suggest **one** advantage of carrying out this trial test **before** carrying out the investigation.

Suggests appropriate advantage of carrying out a trial test ; e.g. learning to identify when the end-point reached

.....

.....

[1]

(v) You are required to prepare different concentrations of the proteins in milk, **M**.

M is undiluted milk and is to be referred to as 100% milk.

You are required to make a simple (proportional) dilution of **M**, which reduces the concentration of **M by 20%** between each successive dilution. You will also need to make a 10% concentration.

You will need to prepare 20cm^3 of each concentration.

You will require these different concentrations of milk for both part (a) and [5] of this question.

Table 1.2 shows how to make up two of the concentrations you will use, 100% and 10%.

Decide which other concentrations of milk to prepare using simple (proportional) dilutions of **M** and complete Table 1.2.

Table 1.2

volume of **M**/ cm^3	volume of distilled water, **W**/ cm^3	concentration of milk/ %
20.0	0.0	100
Concentration of milk: 80, 60, 40, 20; correct volumes which add up to 20; (16/4, 12/8, 8/12, 4/16)		
2.0	18.0	10

[2]

17. Prepare the concentrations of milk as decided in **(a)(v)**.

18. Adjust the temperature of the water-bath so that it is between 35°C and 40°C.
    You will **not** need to maintain this temperature during step 19 to step 24.

19. Put 10cm^3 of the lowest concentration of milk into a test-tube.

    Repeat step 19 with each of the other concentrations of milk that you have prepared and with 100% milk.

    ***Do not** dispose remaining volumes of milk. You will require them in part [b] of this question.*

20. Put 1cm^3 of **C** into each test-tube.

21. Gently shake each of the test-tubes to mix the milk and **C**.

22. Put the test-tubes in the water-bath and leave for at least 3 minutes.

    While you are waiting read step 8 to step 13.

23. After 3 minutes remove one of the test-tubes from the water-bath. Add 1cm^3 of **E** as in step 9, then repeat step 10 to step 13 and record in **(a)(vi)** the time taken to reach the end-point.

24. Repeat step 24 with each of the other test-tubes.

    (vi) Record your results in an appropriate table for the known concentrations of milk.

    1. table drawn + heading, concentration of milk / % + time to reach the end-point/s ;
    2. records at least 3 times for 3 substrate concentrations ;
    3. records the fastest time for the highest concentration of milk ;
    4. records times as whole seconds ;

[4]

You are now required to estimate the protein concentration of **U**.

25. Repeat the experiment with **U**.
    Record in **(a)(vii)** the time taken to reach end-point for **U**.

    (vii) State the time taken for **U** to reach end-point.

    Correct timing (@ between 40% to 80% milk concentration);

[1]

(viii) Complete Fig. 1.4 to show the position on the line of each of the percentage concentrations of milk decided in Table 1.2.
Put the label U on Fig. 1.4 to show an estimate of the concentration of milk which provides a measure of the proteins in **U**, using the result in **(a)(vii)**.
Mark out standard conc on scale;
U marked out at conc between 40 – 80%;

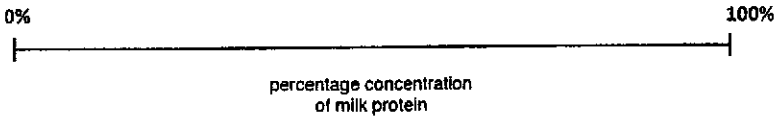

Fig. 1.4

[2]

(ix) Suggest and explain a suitable control experiment that could be used in this investigation.

replaces milk with same volume of water;

to prove/ show that it is the protein in the milk that is coagulated;

or

replaces enzyme with same volume of boiled and cooled enzyme ;

to prove/ show that it is the enzyme that catalysed the coagulation;

.....

.....

.....

.....

[2]

(b) A student suggested that determining protein concentration via the enzyme-catalysed coagulation was too time consuming and there should be a faster method to estimate protein concentration in milk.

You have been provided with the following, which you **must** use:

- Biuret's solution
- spotting tile
- a chart labelled **"colour chart"** provided on the bench

You may use any solutions and apparatus that have been provided.

Plan **and** carry out a method to estimate the concentration of milk protein in **U**.

(i) Outline the steps in your method.

Marking Points:
- Used the same concentrations of milk as (a)*
- CV: constant volume (drops) of milk + constant volume (drops) of biuret's solution [marking for idea of excess biuret soln]
- Compare with colour standard to determine protein concentration in U

Suggested steps:
1 Label the spotting tile with the concentrations of milk prepared in (a).
2 Use a pipette to put (1) drop of 1.0% milk into the labelled well on the tile.
3 Repeat with each of the concentrations of milk.
4 Put (3) drops of Biuret's solution into each of the concentrations of milk on the tile and mix.
5 Compare the colour with the standard colours on the colour chart.
6 Record the colour of the mixture.
7 Perform steps 2-6 on U
8 Compare the colour of U against the colour standard set up.

.....

.....

[3]

(ii) Record your results in a suitable format in the space provided.

- Header 1: concentration of milk proteins/% or protein concentration in milk/%
- Colour:
  - 10% - BLUE,
  - All other tubes - pale violet / violet
- U: 60, 70, 80, 90% or 100% (within table or in a statement);

Concentration of milk proteins/ %	Observations
10	Blue
20	Pale violet
40	Pale violet
60	Violet
80	Violet
100	Violet
U	

U = _____ %

[3]

(iii) Complete Table 1.3 to suggest:

- significant sources of error in your procedure
- improvements to Table 1.3 reduce these errors.

Table 1.3

significant source of error	improvement
Difficulty in matching the colour;	colorimeter;
drop size of milk / drop size of Biuret's solution varies ; AVP;	Keep same volume using small syringe ; AVP ;

[4]

(c) Another student investigated the effect of temperature on the activity of enzyme E, by measuring the percentage coagulation of the milk.

(i) Describe how the temperature could be changed.

use of thermostatically controlled water-bath / hot and cold water in a beaker;

Measure with thermometer;

[2]

The results are shown in Table 1.4.

Table 1.4

temperature / °C	percentage coagulation of the milk
8.5	7
28.0	63
35.5	84
41.0	92
50.0	39

(ii) Plot a graph of the data in Table 1.4 on the grid in Fig. 1.4.

Use a sharp pencil for drawing graphs.

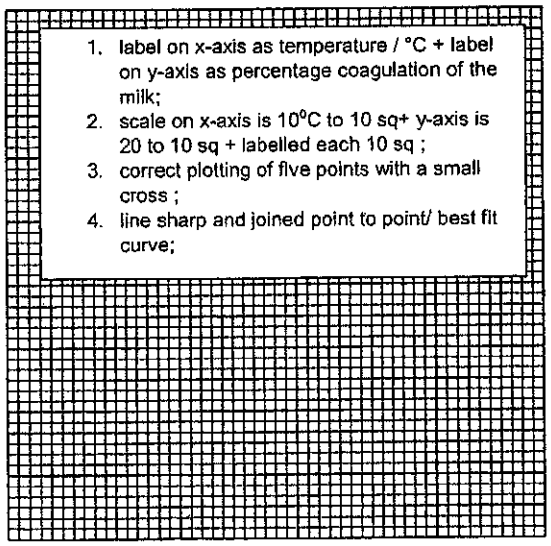

Fig. 1.4

[4]

(iii) Suggest explanations for the results between 35°C and 45°C.

with increasing temperature the enzyme and substrate have more kinetic energy ;

more effective collisions, more ES complexes formed, as temperature increases to 41 °C ;

above 41 °C:

increased thermal agitation, bonds (ionic/ hydrogen) between R groups breaks, specific (3D) structure distorts, active site distorts;

the enzyme denatures;

fewer ES complexes formed;

[3]

[Total: 35]

2 J1 is a slide of a stained transverse section through a plant leaf.

You are not expected to be familiar with this specimen.

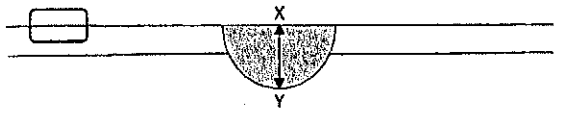

Fig. 2.1

You are required to use a sharp pencil for drawings.

(a) (i) Draw a large plan diagram of the section of the leaf (midrib) shown by the shaded area in Fig. 2.1.

You are expected to draw the correct shape and proportions of the different tissues.

Plan drawing of mid rib (Zea mays)

1 minimum size + no shading + no cells ;

2 at least 4 layers of tissue drawn (upper; two layers; lower);

3 correct shape of the mid rib (bulge at the bottom) and proportion

4 shows subdivision of vascular bundle (xylem and phloem);

5 shows bundle sheath around vascular bundle

[3]

(ii) Use the eyepiece graticule to measure the actual thickness of leaf at position shown by the line X – Y in Fig. 2.1.
Show your working.

At 10x (LP):
@ # EPG: 45 – 50 epg
Thickness = (45-50) x 10µm = 450µm

Distance X – Y ..... [2]

(iii) Observe the upper epidermis at the top of the leaf on J1 shown by the rectangle in the **Fig. 2.1**.

Select one group of **three** cells with:

- two cells from the upper epidermis
- one adjacent (touching) cell from the tissue below.

Each cell of the group must touch at least one of the other cells.
Make a large **labelled** drawing of this group of **three** cells.
Label a structure that produces ATP.

1. Three cells drawn + minimum cell size (at least 4cm) + lines thin and continuous (but not ruled) ;
2. All cells must be drawn with double lines all the way round + where two pairs of cells touch there must be three lines (representing the middle lamella) ;
3. Cell size of epidermal cell larger than palisade cells;
4. Correct shape + inclusion shown within mesophyll cell or epidermal cell ;
5. *label line and label **chloroplast produces ATP** in the mesophyll cells;
6. Label cell wall (one label line which must touch outermost line of a cell or finish between the two cell wall lines), cytoplasm, cell surface membrane, vacuole;

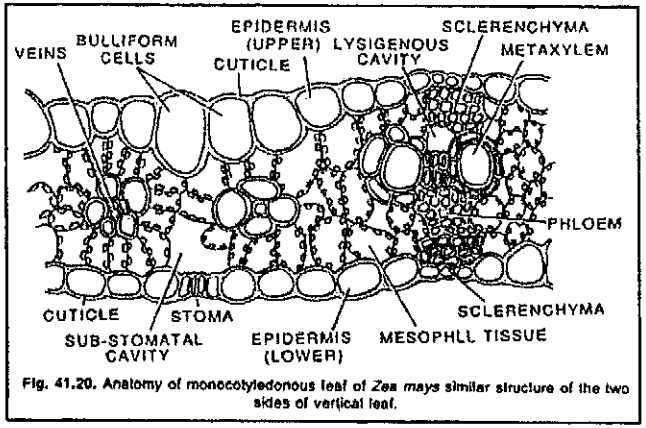

Fig. 41.20. Anatomy of monocotyledonous leaf of *Zea mays* similar structure of the two sides of vertical leaf.

[5]

An eyepiece graticule scale can be used to measure cells. To obtain an actual length the eyepiece graticule scale must be calibrated against a stage micrometer. However, to obtain values for calculating a ratio, it is **not necessary** to calibrate the eyepiece graticule scale.

(iv) Observe J1 using the ×40 objective lens.

Use the eyepiece graticule scale to find the mean width of the
- cells at the upper epidermis
- cells from the tissue below the upper epidermis.

State the ratio of the mean width of the cells at the upper epidermis to the mean width of the cells from the tissue below the upper epidermis.
You may lose marks if you do not show all the steps in finding the ratio.

Cells of upper epidermis = 63/5 (e)gu
Cells of tissue below = 38/5 (e)gu
Cells of upper epidermis divide by cells of tissue below upper epidermis (no units).

- shows measurements for both types of cells + as whole numbers or to 0.5 only + units as "eyepiece", (e)gu or epu ;
- shows division by number of cells (3 or more), for both cell types ;
- larger whole number to smaller whole number + to the lowest common denominator ;

Ratio ..... [3]

(b) Fig 2.2 is a photomicrograph of a stained transverse section through part of a leaf from a different type of plant.

You are not expected to be familiar with this specimen.

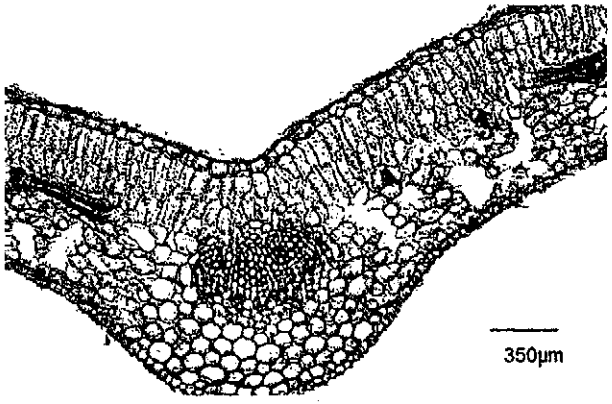

Fig. 2.2

(i) Calculate the magnification of Fig. 2.2 using the scale bar.
You may lose marks if you do not show your working or if you do not use appropriate units.

shows multiplication by 1000 to convert measurement from mm to µm or multiplication by 10000 convert cm to µm (1.3cm) ;

2 displays number divided by 350 ;

3 correct answer ;

magnification × ..... [3]