H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9744/01

Paper 1 Multiple Choice

September 2017

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 and CT on the Answer Sheet in the spaces provided unless this has been done for you.

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.
Calculators may be used.

This document consists of **16** printed pages and **no** blank page.

[Turn over

1 A student has drawn a cell structure as seen using a light microscope.

The magnification of the drawing is ×600.

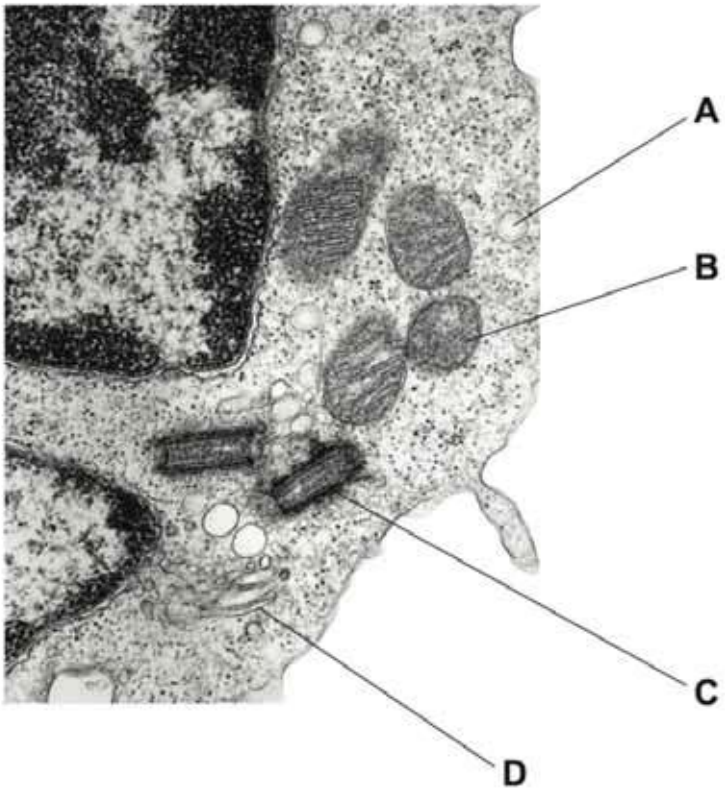
The length of the structure on the drawing is 6mm.

What is the actual length of the cell structure?

A 1×10^{-1} μm **B** 1×10^{0} μm **C** 1×10^{1} μm **D** 1×10^{2} μm

2 The electron micrograph shows part of a eukaryotic cell.

Which of the labelled organelles is a site of protein synthesis?



3 The table shows some information about four carbohydrate polymers.

polymer	α-1,4 glycosidic bonds	α-1,6 glycosidic bonds	shape of molecule
1	✓	✗	helical
2	✗	✓	branched
3	✓	✓	helical
4	✓	✓	branched

key
✓ = present
✗ = absent

Which two polymers form starch?

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

4 When proteins are mixed with some organic solvents, hydrophobic interactions and hydrogen bonding are changed in the protein molecules.

Which levels of protein structure would be affected?

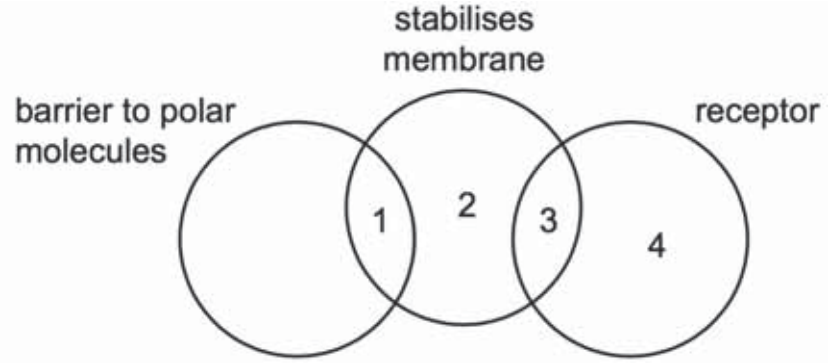
	level of protein structure		
	secondary	tertiary	quaternary
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✓
D	✓	✓	✓

key

✓ = affected

✗ = not affected

5 Which row correctly links molecules in the cell surface membrane with their roles?



	1	2	3	4
A	glycolipid	cholesterol	glycoprotein	phospholipid
B	glycolipid	glycoprotein	phospholipid	cholesterol
C	glycoprotein	phospholipid	cholesterol	glycolipid
D	phospholipid	cholesterol	glycolipid	glycoprotein

6 The table below shows additional information about the enzymes that catalyse some of the reactions in respiration.

enzyme	information
fructose 1,6-bisphosphate aldolase	• four identical subunits • changes to any one of the subunits means that the enzyme cannot function
hexokinase	• one subunit • active site changes shape to enclose the reactants
phosphofructokinase	• four identical subunits • has allosteric sites in addition to an active site
phosphoglucose isomerase	• two identical subunits • has a cytokine function when secreted into the external medium
pyruvate kinase	• four identical subunits • ATP acts as an inhibitor to regulate glycolysis
triosephosphate isomerase	• two identical subunits • each subunit has 14 alpha helices and 8 beta-pleated sheets

A student made the following deductions using the information provided in the table:

- Phosphoglucose isomerase, when secreted, can have a non-catalytic role.
- Only three of the six enzymes display quaternary protein structure.
- The active site of phosphofructokinase will change shape to allow the enzyme to act as a regulator in glycolysis.
- Each enzyme is coded for by one gene.
- The reaction catalysed by hexokinase is an induced-fit mechanism.

How many of the student's deductions are correct and can be supported using the information provided?

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

7 Polypeptide synthesis is based on sequences of three nucleotides, each specific for an amino acid.

Which row shows the correct nucleotide sequences for an amino acid?

	nucleotide sequence of		
	non-transcribed DNA strand	**mRNA codon**	**tRNA anticodon**
A	GGT	CCA	GGU
B	GGG	CCC	CCC
C	CCG	CCG	GGC
D	CCT	CCU	CCU

8 DNA is said to replicate in a semi-conservative way.

Results of Meselson and Stahl's experiments gave overwhelming support to this theory. They used E. coli which has a generation time of 20 minutes.

Here are the steps in their experiment but they are in the wrong order.

P All bacteria contain ^{15}N DNA.
Q All bacteria contain hybrid DNA (^{15}N DNA and ^{14}N DNA).
R Bacteria contain either all ^{14}N DNA or hybrid DNA.
S Bacteria grown in a ^{15}N medium for many generations.
T Bacteria transferred to a ^{14}N medium and sampled every 20 minutes.

Which sequence of letters shows the correct order of the steps in the experiment?

A P→Q→R→S→T
B P→S→T→R→Q
C S→P→T→Q→R
D S→P→T→R→Q

9 The table shows the mode of action of two antibacterial drugs that can affect the synthesis of proteins.

antibacterial drug	rifampicin	streptomycin
mode of action	binds to the RNA polymerase	causes errors in translation

If bacteria are treated with both drugs, what will be the immediate effects?

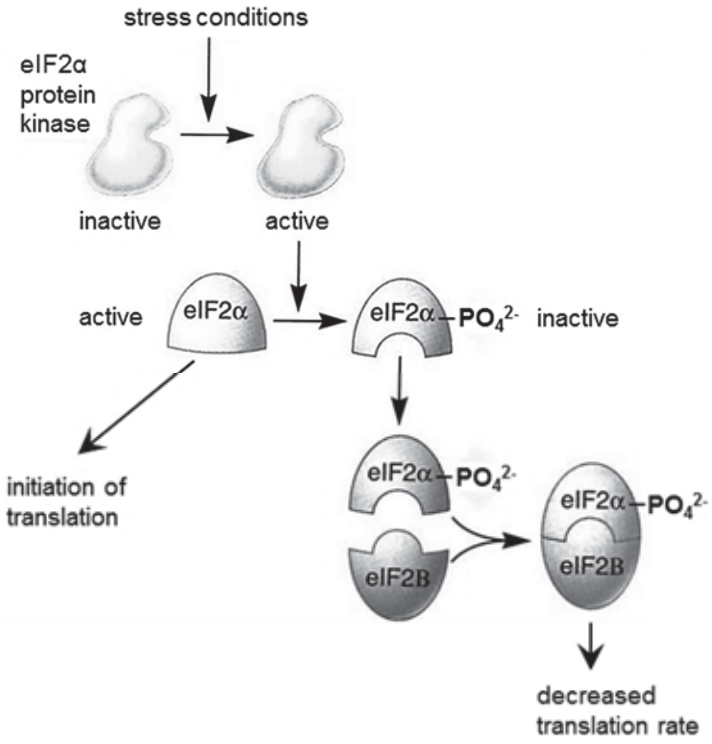
1 Transcription will stop, but faulty proteins may continue to be synthesised.

2 If translation has started, proteins may be faulty.

3 Translation will be inhibited.

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

10 The diagram shows a mechanism by which gene expression is controlled during translation.



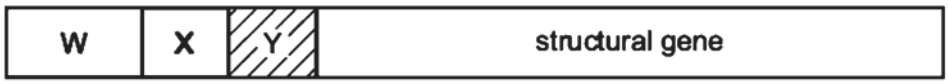
Which statements are correct?

1 Phosphorylation by eIF2α protein kinase changes the conformation of and activates eIF2α.
2 The concentration of eIF2B affects the rate of translation by inhibiting translation initiation.
3 This regulation results in decreased rate of mRNA translation under stress conditions.
4 The eIF2α-eIF2B complex is recognised by proteasomes for selective degradation due to the presence of the phosphate group.

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

11 The diagram represents a length of DNA from a prokaryote that includes a structural gene.

Parts of the length of DNA are labelled **W**, **X** and **Y**. They have different functions in the control of transcription of the structural gene.



What identifies the functions of parts **W**, **X** and **Y**?

	W	X	Y
A	operator	regulator	promoter
B	promoter	regulator	operator
C	regulator	promoter	operator
D	promoter	operator	promoter

12 Which of the following statements concerning lac operon is true?

1 Transcription of lac operon takes place all the time.

2 There is one single mRNA transcribed from the lac operon.

3 There is one start and one stop codon in the mRNA of lac operon.

4 The repressor molecule binds to the operator to turn off lac operon.

A 4 only

B 1 and 3

C 2 and 4

D 2, 3 and 4

13 Some events that take place during generalised transduction are listed below.

1 Bacterial host DNA is fragmented.
2 Bacterial DNA may be packaged in a phage capsid.
3 Recombination between donor bacterial DNA and recipient bacterial DNA.
4 Phage infects a bacterial cell.
5 Phage DNA and proteins are made.

Which sequence of events is correct?

A 4 1 3 5 2

B 4 1 5 2 3

C 4 5 2 3 1

D 4 5 1 3 2

14 What are the conditions in a human cell just before the cell enters prophase?

	number of molecules of DNA in nucleus	spindle present	nuclear envelope present
A	46	yes	no
B	46	no	yes
C	92	yes	yes
D	92	no	yes

15 The following table shows the chromosome numbers in the hybrids formed between cabbage (*Brassica oleracea*) and radish (*Raphanus sativus*).

type of cell	*no. of chromosomes per cell*
parental cabbage	18
parental radish	18
parental gametes	9
F_1 hybrids	18
F_1 gametes	18
F_2 hybrids	36
F_2 gametes	18
F_3 hybrids	36

During which of the following stages can the occurrence of non-disjunction explain the results?

A formation of the F_1 gametes

B formation of the F_2 gametes

C fusion of the parental gametes

D fusion of the F1 gametes

16 The statements are about genes and proteins, involved in breast cancer.

- The main protein coded by *BRCA1* gene inhibits the growth of breast cancer cells.
- The protein coded by the *p53* gene suppresses tumours.

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

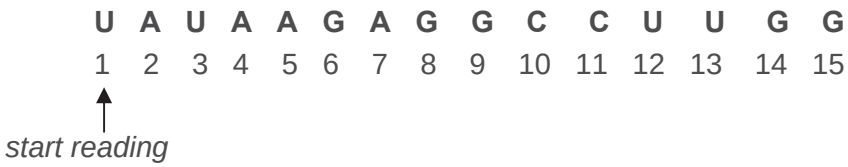
	gene	
	BRCA1	*p53*
A	×	×
B	×	✓
C	✓	×
D	✓	✓

key
✓ = normal active gene
× = mutated gene

17 The following table shows the mRNA codons for six different amino acids.

mRNA codons	amino acid
AAA AAG	lysine
AGA AGG CGG	arginine
GGU GGA GGC GGG	glycine
CCU CCA CCC CCG	proline
UGG	tryptophan
UAU UAC	tyrosine

The base sequence of mRNA coding for part of a polypeptide is shown below.



From the information provided, which of the predictions stated below is **not** true?

A The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.

B The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.

C The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.

D The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

18 Skin colour in onions is controlled by two pairs of alleles **Ss** and **Rr**, which segregate independently. The allele **S** is dominant and must be present to allow development of pigment in the skin. In its absence, the onion skin is white. Allele **R** is dominant and gives red colour; the recessive r gives yellow colour.

What will be the ratio of phenotypes in the offspring of a cross between plants of genotypes **SsRR** and **ssrr**?

A all red

B 1 red : 1 yellow

C 1 red : 1 white

D 1 white : 2 red : 1 yellow

19 Which of the following would cause phenotypic variation among organisms of the same genotype?

A continuous variation within the species

B different varieties of the same species

C exposure to different environments

D mutation

20 A tall, green-stemmed plant with the genotype **TTrr** was crossed to a short, red-stemmed plant with the genotype **ttRR.** The F1 plants were allowed to self-fertilise. A χ^2 test was carried out on the results obtained for the F2 generation.

Part of the table of values for χ^2 is shown.

degrees of freedom	p = 0.5	p = 0.1	p = 0.05	p = 0.01	p = 0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.6	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.36	7.78	9.49	13.28	18.46
5	4.35	9.24	11.07	15.09	20.52

The value of χ^2 in this investigation was 7.6.
What is the probability of this value of χ^2 and do the results fit the expected ratio?

	probability	results fit expected ratio
A	between 0.001 and 0.01	no
B	between 0.01 and 0.05	yes
C	between 0.05 and 0.1	yes
D	between 0.1 and 0.5	no

21 In a series of experiments, actively photosynthesizing plants were supplied with labelled reactants.

1 water containing ^{18}O isotope

2 carbon dioxide containing ^{17}O isotope

3 carbon dioxide containing ^{13}C isotope

Where in the chloroplast would the products of photosynthesis from these reactants be formed?

	^{18}O	^{17}O	^{13}C
A	stroma	stroma	thylakoids
B	stroma	thylakoids	stroma
C	thylakoids	stroma	stroma
D	thylakoids	stroma	thylakoids

22 In an experiment, four tubes were set up as shown in the table below.

tube	contents
1	Glucose + homogenized animal cells
2	Glucose + mitochondria
3	Glucose + cytoplasm lacking organelles
4	Pyruvate + homogenized animal cells

If all other conditions are kept constant, which of the following shows the amount of ATP produced in each tube in **increasing** order?

A 1 – 3 – 4 – 2

B 2 – 3 – 4 – 1

C 4 – 2 – 3 – 1

D 3 – 2 – 1 – 4

23 Which of the following correctly describes the function of second messenger in signal transduction pathway?

A They relay the signal from the outside to the inside of the cell.

B They serve as transcription factors to activate the transcription process.

C They amplify the message by directly phosphorylating the cascades of proteins.

D They relay the message from the inside of the membrane throughout the cytoplasm.

24 Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation?

A	adaptation of population	→	competition and predation leading to natural selection	→	behavioural isolation	→	sympatric speciation
B	adaptation of population	→	competition and predation leading to natural selection	→	behavioural isolation	→	allopatric speciation
C	competition and predation leading to natural selection	→	geographical isolation	→	adaptation of isolated populations	→	sympatric speciation
D	competition and predation leading to natural selection	→	geographical isolation	→	adaptation of isolated populations	→	allopatric speciation

25 Natural selection acts

A directly on an individual's genetic make-up, thereby changing the survival probability of the individual.

B on individuals by changing their genes so they are better able to adapt to their environment.

C on the structures, physiologies and behaviours expressed by individuals in a population to change allele frequencies.

D on phenotypes of individuals so that they change to adapt to their environment and pass on these changes to their offspring.

26 The map shows the distribution (shaded area) of the lizards belonging to the family Iguanidae. Most species of iguana are found in America but a few species inhabit Madagascar and the islands of Fiji (arrows at the bottom centre and bottom right of map).

Two observations were made about the different species of iguana:

1 The various American iguana species shared more similar characteristics among themselves than with those iguana species on the island of Fiji.

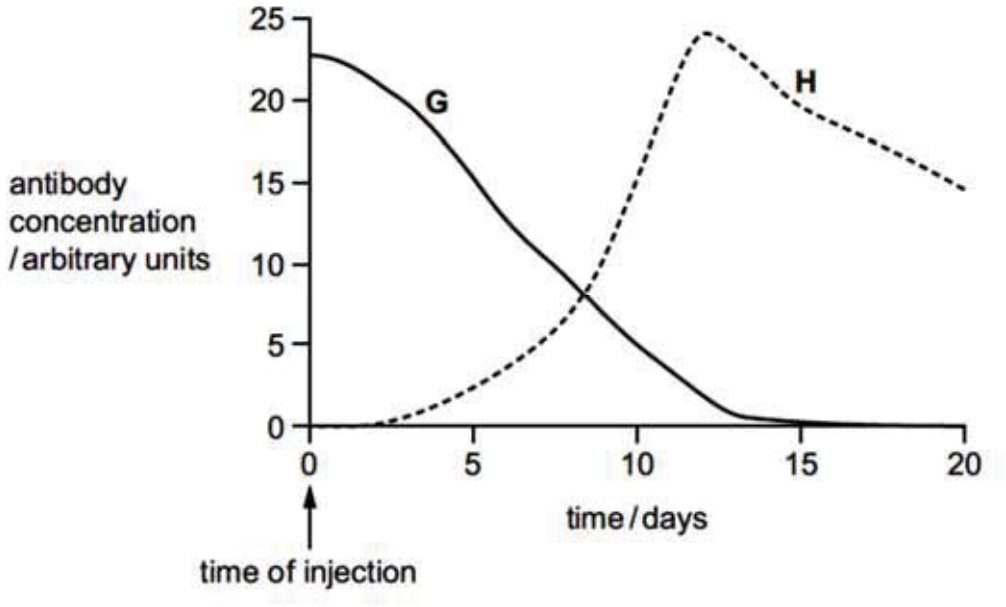
2 The Madagascar iguana species was only distantly related to other lizard species on the African mainland.

Which observation and explanation best support the Darwinian concept of descent with modification?

	Observation	Explanation for the observation
A	1	The various American iguana species had a more recent common ancestor as compared to those iguana species on the island of Fiji that had diverged a longer time ago.
B	1	The various American iguana species shared more similarities among themselves as the degree of homology in their DNA was higher.
C	2	The Madagascan iguana species was reproductively isolated from the lizard species on the African mainland and thus diverged a long time ago.
D	2	The superficial similarities shared among the Madagascan iguana and the lizards on the African mainland were analogous, not homologous.

27 Two people, **G** and **H**, were each given an injection to protect them against a particular pathogen.

One person was injected with antibodies. The other person was injected with a vaccine. The graph shows the concentrations of the antibody against this pathogen in the blood of the two people, **G** and **H**, over a period of 20 days following the injection.



Which row correctly describes the type of immunity shown by **G** and **H**?

	G	H
A	artificial active immunity	artificial passive immunity
B	artificial passive immunity	artificial active immunity
C	natural active immunity	natural passive immunity
D	natural passive immunity	artificial active immunity

28 Which of the statements could describe **both** B-lymphocytes and T-lymphocytes?

1 They contain specific protein receptors in their cell surface membranes.
2 They differentiate into plasma cells.
3 They divide by mitosis.

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

29 What is the best definition of the greenhouse effect in the Earth's atmosphere?

A A naturally occurring effect by which shorter wavelength radiation is trapped

B A naturally occurring effect by which longer wavelength radiation is trapped

C An effect of pollution by which shorter wavelength radiation is trapped

D An effect of pollution by which longer wavelength radiation is trapped

30 Global warming caused by the enhanced greenhouse effect is likely to have major consequences for arctic ecosystems. Which of the following are likely to occur in the arctic if the Earth's surface temperature rises?

I Decreased rates of decomposition of detritus
II Increased range of predators from temperate regions
III Increase in numbers of pest species and pathogens

A I and II only

B I and III only

C II and III only

D I, II and III

H

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Paper 2 Structured Questions

September 2017

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	
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10	
Total	

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

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

1 **Table 1** shows some features of four biological molecules that are all polymers.

(a) Complete Table 1 by using a tick (✓) to indicate the features that apply to each polymer.

Table 1

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				
contains glycosidic bonds				
polymer is branched				
contains nitrogen				
can be found in both animal and plant cells				

[4]

(b) **Fig. 1** is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate **Fig. 1** as part of your answer.

Fig. 1

.....

.....

.....

.....

.....

.....

[3]

(c) State two components of a cell surface membrane other than phospholipid molecules and describe their function.

component 1

function

component 2

function

[4]

The fluid mosaic model of membrane structure was first proposed in 1972 by Singer and Nicolson. The model describes in detail how the components of a membrane are organised.

(d) Suggest why 'fluid mosaic' is an appropriate term to use to describe membrane structure.

[3]

[Total: 14]

2 Erythropoietin, also known as EPO, is a large glycoprotein synthesised by specialised cells in the kidney. These cells are very sensitive to changes in oxygen concentration in the blood passing through the kidney and respond to a low oxygen concentration by increasing the synthesis of EPO.

EPO acts at the surface of particular target cells, such as cells in the bone marrow. These bone marrow cells are stimulated to produce red blood cells.

(a) A low oxygen concentration leads to an increase in the quantity of mRNA in the specialised cells in the kidney by activating hypoxia-inducing factors (HIFs) which regulates gene expression at the transcriptional level.

Explain how the activation of HIFs results in an increase in EPO mRNA in the cells.

[3]

(b) All cells of the body are exposed to circulating blood plasma containing EPO, but only particular target cells respond.

(i) Suggest why EPO acts on target cells and not other cells.

[2]

(ii) EPO cannot pass through the cell surface membrane to enter the bone marrow cells. Suggest **one** reason why this is so.

[1]

(c) Red blood cells originate from undifferentiated cells in the bone marrow that are capable of continuous mitotic cell division.
State the name of this type of undifferentiated cell.

[1]

[Total: 7]

3 **(a)** **Fig. 3** is a diagram of an ATP molecule.

Label **Fig. 3** to show the components of an ATP molecule.

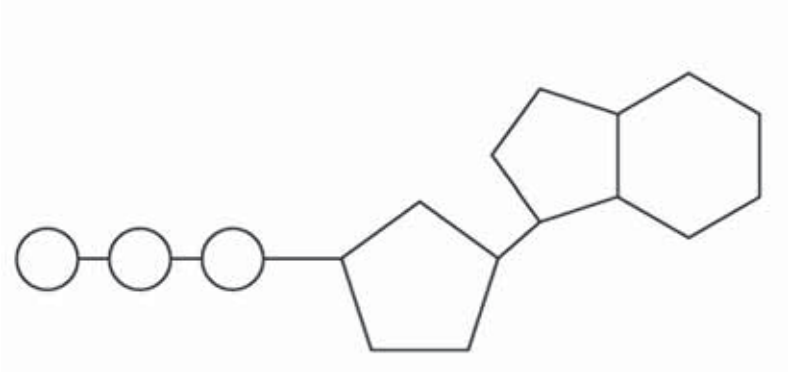

Fig. 3 [3]

(b) ATP is used during translation in amino acid activation, when an amino acid becomes attached to its specific tRNA molecule having a particular anticodon. The reaction requires an enzyme called aminoacyl tRNA synthetase.

(i) Explain why a particular amino acid needs to be linked to a specific tRNA molecule.

.....

.....

.....

.....

[2]

(ii) Explain how the structure of an enzyme such as aminoacyl tRNA synthetase would be altered if the pH of the cytoplasm became too acidic.

.....

.....

.....

.....

[2]

(iii) Aminoacyl tRNA synthetase uses the induced fit mechanism.

Explain the induced fit mechanism.

.....

.....

.....

.....

[2]

[Total: 9]

4 *Morbillivirus* causes measles. The structure of *Morbillivirus* is shown in **Fig. 4**.

Haemagglutinin (H) and fusion protein (F) are glycoproteins embedded in the viral envelope.

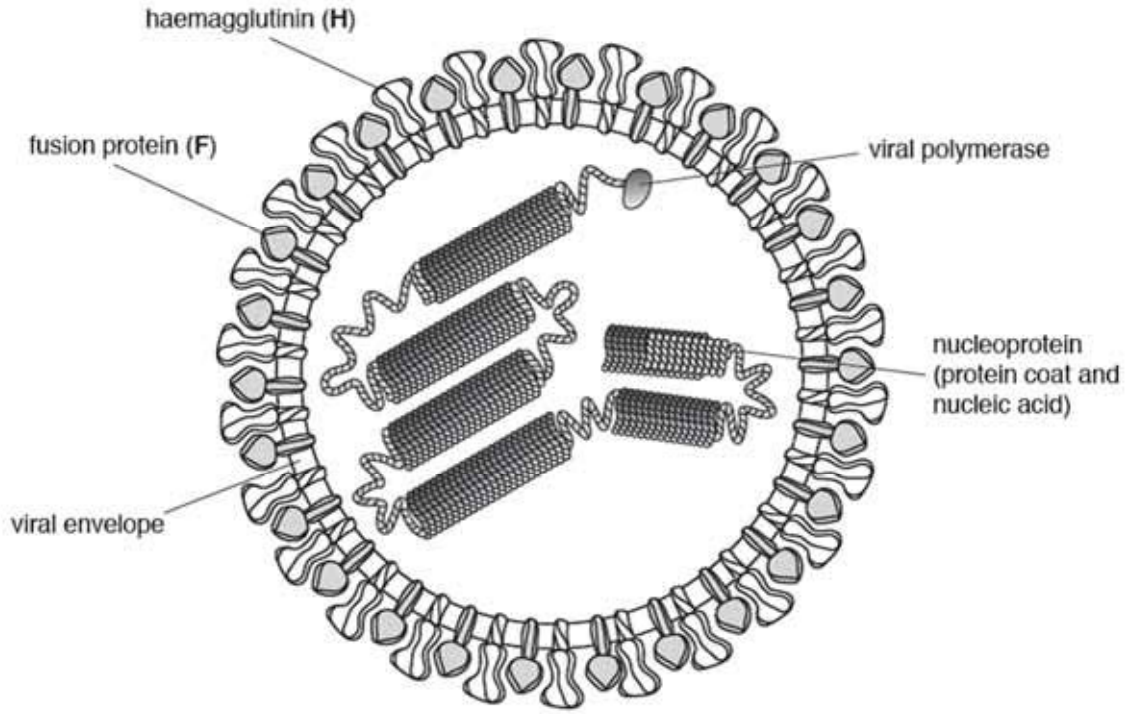

Fig. 4

Morbillivirus only infects cells that have a membrane glycoprotein known as signalling lymphocyte activation molecule (SLAM).

When *Morbillivirus* infects a cell, **H** acts before **F**. After the virus binds to the host cell, only the nucleoprotein with the viral polymerase enters the host cell and the virus is replicated.

Morbillivirus replicates its genetic material in the same manner as influenza virus.

New viral particles leave the host cell by budding from the cell surface membrane of the cell. This forms the main part of their envelope.

(a) List two ways in which the structure of *Morbillivirus*:

(i) is similar to HIV

.....

.....

.....

.....

[2]

(ii) differs from the HIV

[2]

(b) With reference to **Fig. 4.1** and the information provided,

(i) suggest how *Morbillivirus* infects a cell with SLAM glycoproteins so that only nucleoprotein and viral polymerase enter.

[2]

(ii) suggest the role of viral polymerase in *Morbillivirus*.

[3]

(c) Measles has only one serotype. Within this serotype, there are 24 genotypes recognised to date.

Describe how these 24 genotypes could have arisen.

[2]

[Total: 11]

5 An *Allium cepa* root was cut into ten transverse sections at different distances from the tip. The sections were stained and viewed under the microscope. The number of cells in mitosis were counted in each section and the results were used to determine the mitotic index.

This is calculated as follows:

$$\text{mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}}$$

Fig. 5.1 shows the mitotic index for the ten sections.

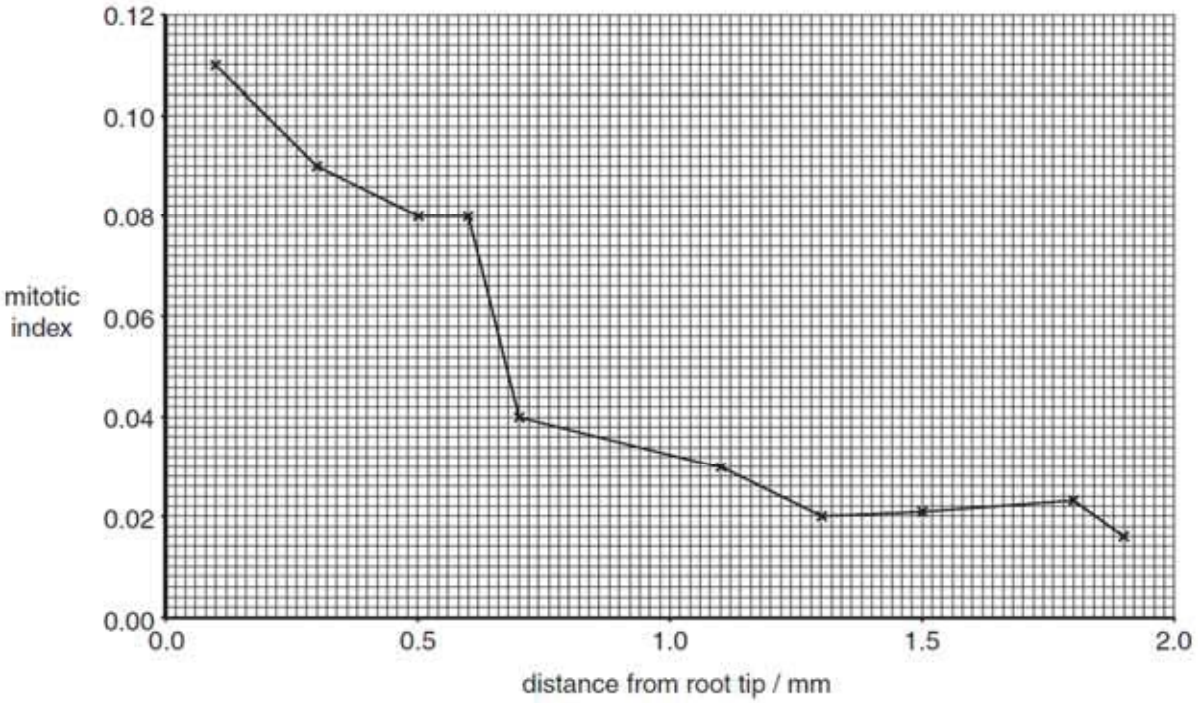

Fig. 5.1

(a) Using the information in **Fig. 5.1**, describe how the mitotic index changes along the length of the root.

.....

.....

.....

.....

[2]

(b) Explain how the events in the mitotic cell cycle ensure that all the cells in the root are genetically identical.

[3]

(c) Two genes, **A/a** and **B/b** are linked on the same pair of homologous chromosomes in *Allium cepa*, as shown in **Fig. 5.2**.

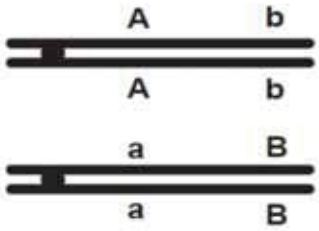

Fig. 5.2

With reference to **Fig. 5.2**,

(i) draw a diagram to show the effect of crossing-over between the homologous chromosomes.

[2]

(ii) state the effect of linkage and crossing-over on the proportions of gametes with different genotypes that are produced.

[2]

[Total: 9]

6 *CFTR*, the cystic fibrosis (CF) gene, encodes for the CFTR protein that plays an essential role in anion regulation and tissue homeostasis of various epithelia. In the gastrointestinal tract CFTR promotes chloride and bicarbonate secretion, playing an essential role in ion and acid-base homeostasis.

Gene mutations responsible for cystic fibrosis can be classified into 6 different classes.

- **Class I** mutations can result from nonsense and frame-shift mutations, as well as mRNA splicing defects.
- **Class III and IV** mutations are typified by aberrant channel function, rather than reduced quantities of CFTR.

(a) Explain how **Class I** mutations result in a reduction in the quantity of functional CFTR protein.

[2]

(b) Explain how **Class III** and **IV** mutations result in aberrant channel function.

[2]

CFTR, has been identified as a candidate driver gene for colorectal cancer in mice and humans. Further, recent epidemiological and clinical studies indicate that CF patients are at high risk for developing tumours in the colon. Investigations suggest that *CFTR* is a ***tumour suppressor gene*** in the intestinal tract as *CFTR* mutant mice developed significantly more tumours in the colon and the entire small intestine.

(c) Explain why a mutation in the tumour suppressor gene, such as the *CFTR* gene, may lead to significantly more tumours in mice.

[3]

(d) Suggest how tumours can eventually become malignant, leading to cancer.

[2]

[Total: 9]

7 **(a)** Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, I^A, I^B and I^o. Alleles I^A and I^B are codominant and I^o is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

[3]

(b) In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

[3]

(c) A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black ($\mathbf{C^B}$) and splashed-white ($\mathbf{C^W}$). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

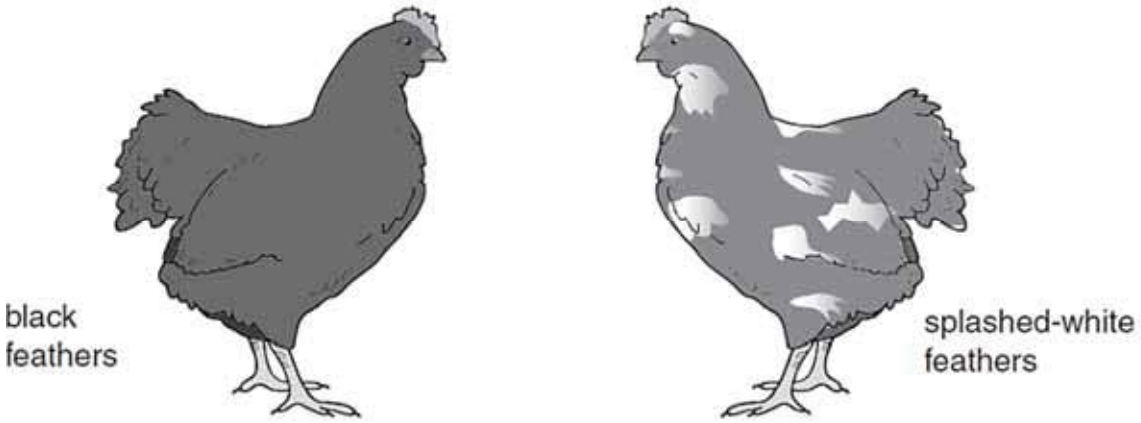

Fig. 7.1

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers ($\mathbf{X^A}$) is dominant to the allele for nonbarred feathers ($\mathbf{X^a}$).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.

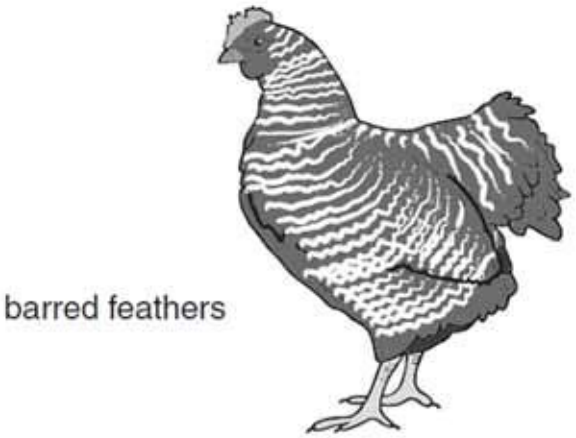

Fig. 7.2

(i) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above, draw a genetic diagram to show this cross.

parents' phenotype	male, black, non-barred feathers.	female, splashed-white, barred feathers.
genotype		
gametes		
offspring genotypes		
phenotypes	male, blue, barred feathers.	female, blue, non-barred feathers.

[3]

(ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

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[3]

[Total: 12]

8 Heart muscle cells and epidermal cells were extracted from Chinese hamsters. The cells were lysed and the mitochondria and cytosol were isolated. The mitochondria and cytosol were then mixed and re-suspended in a culture of essential nutrients. This suspension system was used to study the process of cellular respiration.

At time **0**, glucose was added to the system. At Time **X**, digitonin, a detergent which disrupts membranes was introduced to the suspension system. A probe was used to measure the concentrations of ATP as well as the pH level in the mitochondria.

The experimental results are recorded in the graphs shown.
Fig. 8.1 shows the rate of ATP production for heart muscle cells and epidermal cells.
Fig. 8.2 shows the pH level of the mitochondria in both heart muscle and epidermal cells.

Fig. 8.1

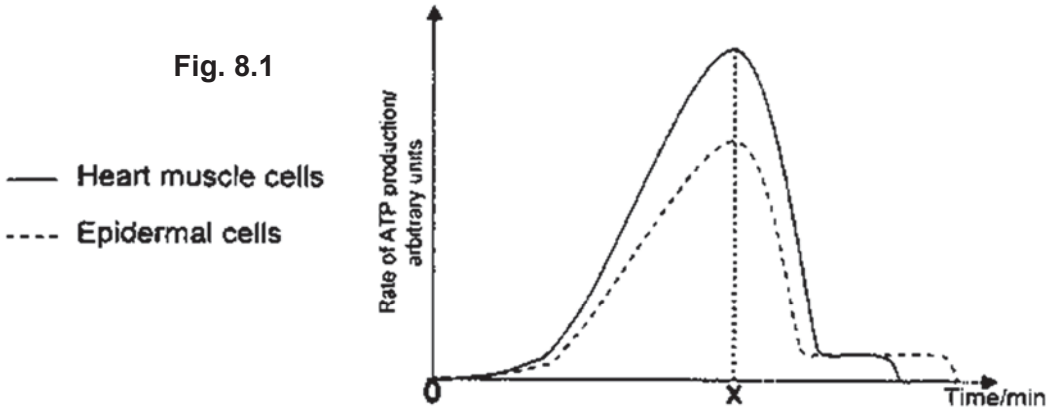
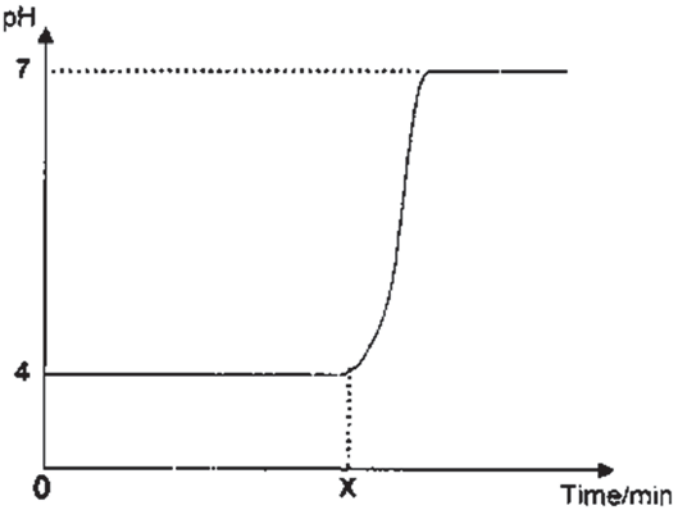


Fig. 8.2



(a) Account for the difference in the level of ATP production in both tissues after glucose was added.

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[1]

(b) With reference to **Fig. 8.1**, explain the changes in ATP production over time for the heart muscle cell suspension.

[3]

(c) With reference to **Fig. 8.2**, state which region of the mitochondrion the pH probe was measuring. Explain your conclusion.

[2]

(d) Suggest why cytosol was used to re-suspend the mitochondria.

[1]

(e) From your biological knowledge, explain the adaptation of the double membrane for its role in the production of energy.

[2]

[Total: 9]

9 The camel family, Camelidae, are well-known for their ability to survive the hot and dry conditions of the desert, but studies have found that they once thrived in colder climates. A recent finding by a group of scientists unearthed fossilised remains of a giant species of camel in North America. This giant species of camel is closely-related to the one-humped Dromedary camel now found in Africa (**Fig. 9.1**). The distinctive humps of both camels are fat stores.

Dromedary camel **Giant camel**

Fig. 9.1

(a) Suggest how the presence of hump in both the ancestral Giant camel and modern-day Dromedary camel allow them to adapt to their respective habitats.

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.....

[2]

Until only about two or three million years ago, the Camelids were largely confined within North America. Following the formation of the Bering Land Bridge and the Isthmus of Panama, camels migrated from North America to Asia and South America respectively. Today, camels are no longer found in North America.

Three modern-day groups of species survive today:

- the one-hump Dromedary camel of north Africa and southwest Asia,
- the two-hump Bactrian camel of central Asia and
- the South American Camelids group which has diverged into four species: llamas, alpacas, guanacos, and vicuñas.

Fig. 9.2 shows the distribution of modern-day camels in the world.

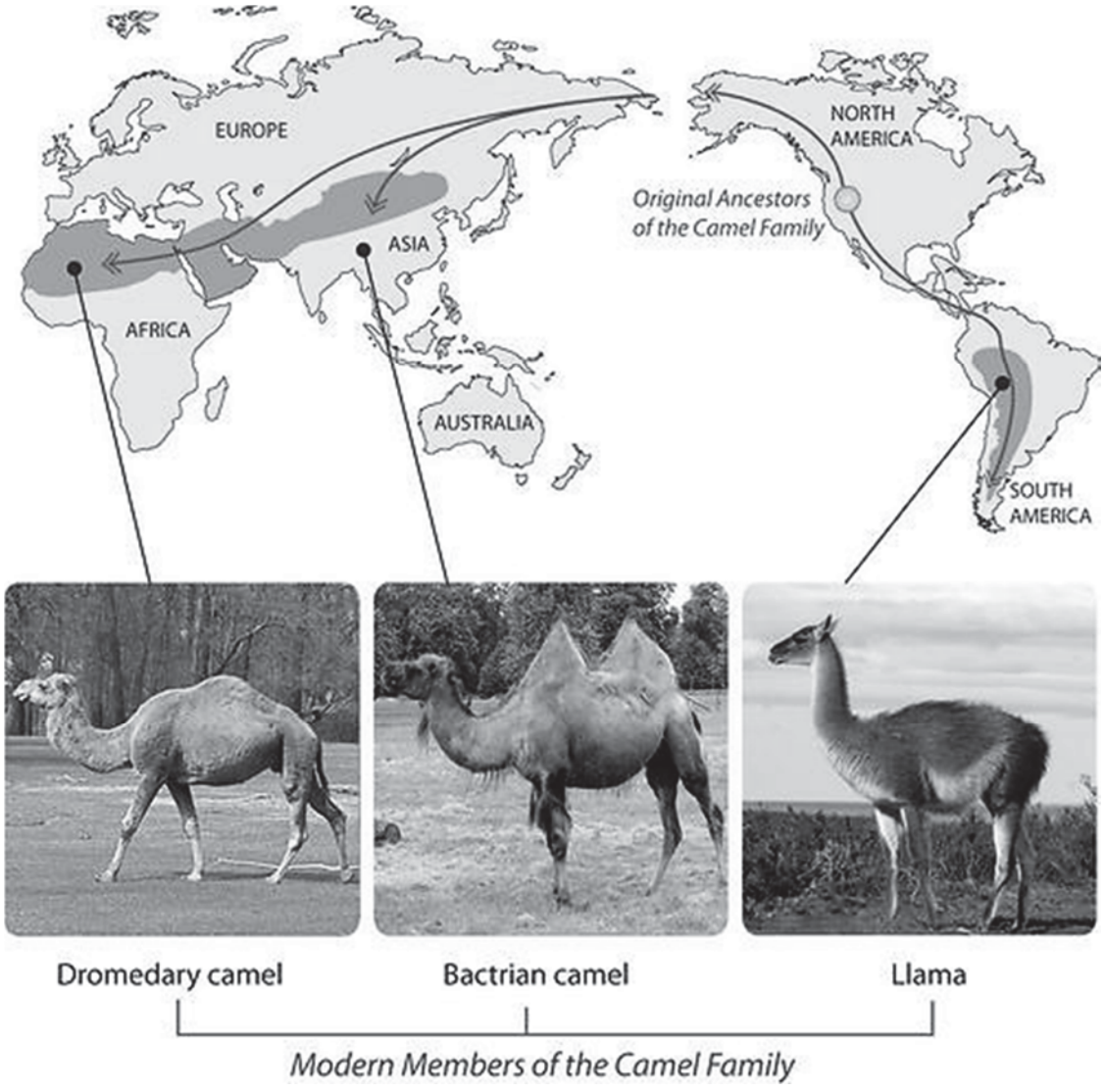

Fig. 9.2

The various species of the modern-day camels evolved from the ancestral population in North America.

(b) With reference to **Fig. 9.2**, describe how natural selection could have occurred to give rise to the various species of camels in the world today.

[4]

(c) The Arabian camels in Australia typically have sand coat colour. However, there is a small percentage of camels which have albino coat. It is known that the albino coat is a recessive condition and it reduces the life-span of the camel. The population of the sand coat and albino coat camels in a region was documented.

(i) Explain why population is considered the smallest unit of evolution.

[2]

(ii) Explain whether it is likely that the albino camel will disappear completely from the population over time. Assume there is no introduction of new albino camels into the population.

[2]

[Total: 10]

10 (a) The infectious disease tuberculosis (TB) is caused by a bacterium.

Each of the descriptions **A** to **C** describes a cell structure found in prokaryotic cells **and** in plant cells.

For each of the descriptions **A** to **C**:

- name the cell structure described
- state **one** difference in this structure between a prokaryotic cell and a plant cell.

A the site of polypeptide synthesis

cell structure

difference

B the genetic material of the cell

cell structure

difference

C the structure that provides a rigid shape to the cell and prevents osmotic lysis

cell structure

difference

[3]

(b) Describe how TB is transmitted from an infected person to an uninfected person.

[2]

(c) Outline how the use of vaccine can give protection against diseases such as tuberculosis.

[5]

[Total: 10]

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **September 2017**

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 About one third of the injuries to racehorses involve tendon damage. In 2006, bone marrow stem cells were taken from injured racehorses and cultured so that they divided many times by mitosis. Each horse's cells were then injected into its damaged tendons. 80% of the treated horses returned to racing, compared with 30% of those treated conventionally.

(a) Adult stem cells such as these are described as multipotent.

Explain what is meant by the term *multipotent*.

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[1]

(b) In these treatment procedures, the bone marrow stem cells are stimulated to increase their rates of cell division so as to produce large enough numbers of cells to be injected into the horses.

Using your knowledge of cell signalling, describe how the rate of mitosis can be controlled.

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[4]

(c) Suggest how it is possible that bone marrow stem cells could differentiate into the range of cell types needed for repairing injuries.

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[2]

Like most mammals, T cell (T lymphocytes) in horses differentiate inside the thymus gland. During T cell differentiation, specific cell surface proteins known as CD proteins are produced and inserted into the cell surface membrane.

Fig. 1 shows the stages involved in the synthesis of a CD protein in a T cell.

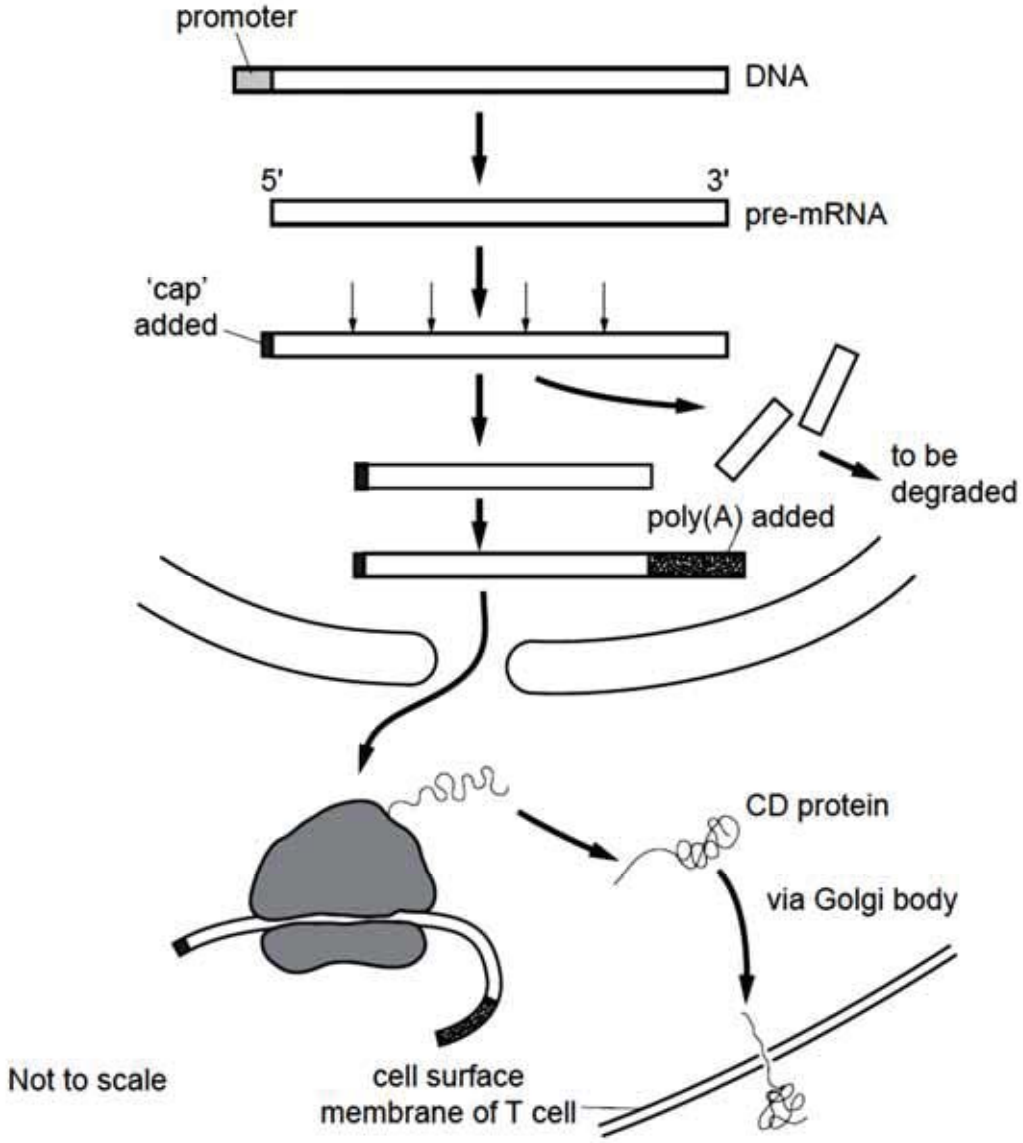

Fig. 1

(d) Explain the function of the promoter region of the DNA.

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[2]

(e) Using **Fig. 1** as a guide, describe the events that occur in the nucleus of the T cell to produce a pre-mRNA encoding a CD protein.

[3]

(f) Explain why the cuts made in pre-mRNA are necessary for the T cell to produce a functional CD protein.

[3]

(g) Explain the functions for the 'cap' and the poly-A region attached to the mRNA.

[2]

[Total: 17]

2 Lactate dehydrogenase (LDH) is an enzyme found in many organisms. Within the same organism, it can be found in different forms, called isoenzymes. The isoenzymes are structurally different but all catalyse the same reaction.

(a) **Fig. 2.1** shows a reaction catalysed by lactate dehydrogenase that occurs during anaerobic respiration in muscle tissue.

(i) Complete **Fig. 2.1** by identifying the compounds **A**, **B** and **C**.

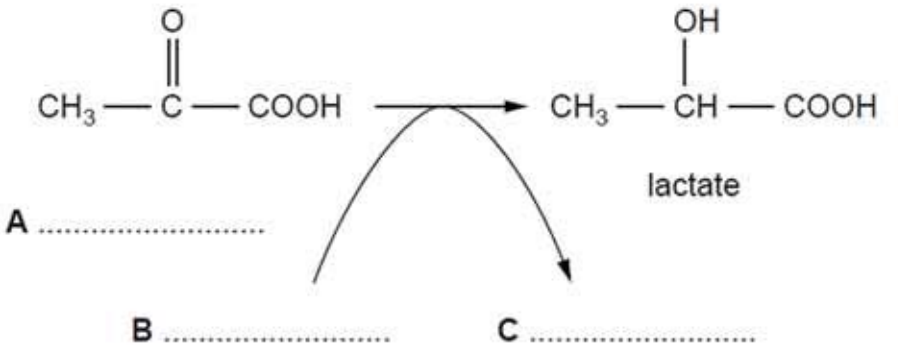

Fig. 2.1

[2]

(ii) State where in the cell this reaction takes place.

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[1]

(iii) Explain the importance of this reaction in mammalian muscle tissue.

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[3]

Lactate dehydrogenase isoenzymes are globular proteins, each consisting of four polypeptides.

(b) Explain how the structure of an enzyme, such as lactate dehydrogenase is suited to its role.

[4]

Lactate dehydrogenase isoenzymes are made up of two types of polypeptide:

- polypeptide M, which is coded for by the *LDH-A* gene and
- polypeptide H, which is coded for by the *LDH-B* gene.

Table 2 shows the composition of different human lactate dehydrogenase isoenzymes and examples of tissues and organs where each can be found.

Table 2

isoenzyme	polypeptide composition of enzyme	example of isoenzyme location
LDH-1	HHHH	heart red blood cells
LDH-2	HHHM	heart red blood cells
LDH-3	HHMM	brain lungs
LDH-4	HMMM	kidneys placenta
LDH-5	MMMM	liver skeletal muscles

(c) With reference to **Table 2,** suggest how red blood cells of the same individual can produce different isoenzymes.

[2]

Besides lactate dehydrogenase, another extensively studied protein which is also involved in respiration is cytochrome c. Cytochrome c plays an important role in oxidative phosphorylation as an electron carrier of the electron transport chain.

(d) **Fig. 2.2** shows the amino acid sequence of a section of the cytochrome c polypeptide chain retrieved from a human and the other species. The dashes shown in the figure indicates that the amino acid present at the position is identical to that of the human species.

Molecular homology of cytochrome c

		1					6				10				14			17	18		20		
Human		Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Ile	Met	Lys	Cys	Ser	Gln	Cys	His	Thr	Val	Glu	Lys
Pig		-	-	-	-	-	-	-	-	-	-	Val	Gln	-	-	Ala	-	-	-	-	-	-	-
Chicken		-	-	Ile	-	-	-	-	-	-	-	Val	Gln	-	-	-	-	-	-	-	-	-	-
Dogfish		-	-	-	-	-	-	-	-	Val	-	Val	Gln	-	-	Ala	-	-	-	-	-	-	Asn
Drosophila	<<<	-	-	-	-	-	-	-	-	Leu	-	Val	Gln	Arg	-	Ala	-	-	-	-	-	-	Ala
Wheat	<<<	-	Asn	Pro	Asp	Ala	-	Ala	-	-	-	Lys	Thr	-	-	Ala	-	-	-	-	-	Asp	Ala
Yeast	<<<	-	Ser	Ala	Lys	-	-	Ala	Thr	Leu	-	Lys	Thr	Arg	-	Glu	Leu	-	-	-	-	-	-

Fig. 2.2

(i) Suggest what the data in **Fig. 2.2** indicate about the evolutionary relationships between humans and the other species.

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[3]

(ii) Explain why any such conclusions in **(i)** need to be treated with caution.

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[2]

(e) Suggest how the differences in the amino acid sequences shown in **Fig. 2.2** may have come about.

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[2]

(f) Suggest why the cytochrome c protein was chosen to compare amino acid sequences across the different species.

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[1]

[Total: 20]

3 Dengue fever (DF) is a disease caused by infection with a virus transmitted by the *Aedes aegypti* mosquito. It is an acute viral infection characterized by fever, rash, headache and muscle and joint pain. Occasionally, dengue virus infections progress to dengue haemorrhagic fever (DHF) and dengue shock syndrome (DSS).

There are 4 known serotypes of the disease-causing dengue virus. Individuals who become infected with one serotype obtain lifelong immunity against that serotype but not the other three.

Female *Aedes* mosquitoes are responsible for human-to-human transmission of the dengue virus. During blood feed, they acquire the proteins necessary for them to develop eggs. As a result of their short life cycle, they are able to multiply quickly, allowing dengue to spread.

(a) (i) State one reason why blood is a good source of protein.

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[1]

(ii) Outline the life cycle of the *Aedes aegypti*.

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[4]

Aedes aegypti originated in Africa but migrated to other continents via the slave trade in the 1500s and 1600s. The estimated range of the mosquito is primarily the tropics and sub-tropics but they have also been detected in countries with temperate climate such as parts of Europe and North America. As a result of the spread of *Aedes* vector across the globe, worldwide incidences of dengue have also been on the rise, posing huge public health concerns.

Fig. 3.1 shows the annual average number of both DF and DHF reported to the World Health Organisation (WHO) and the average annual number of countries reporting these cases from 1955 to 2007. The upward trend continues today.

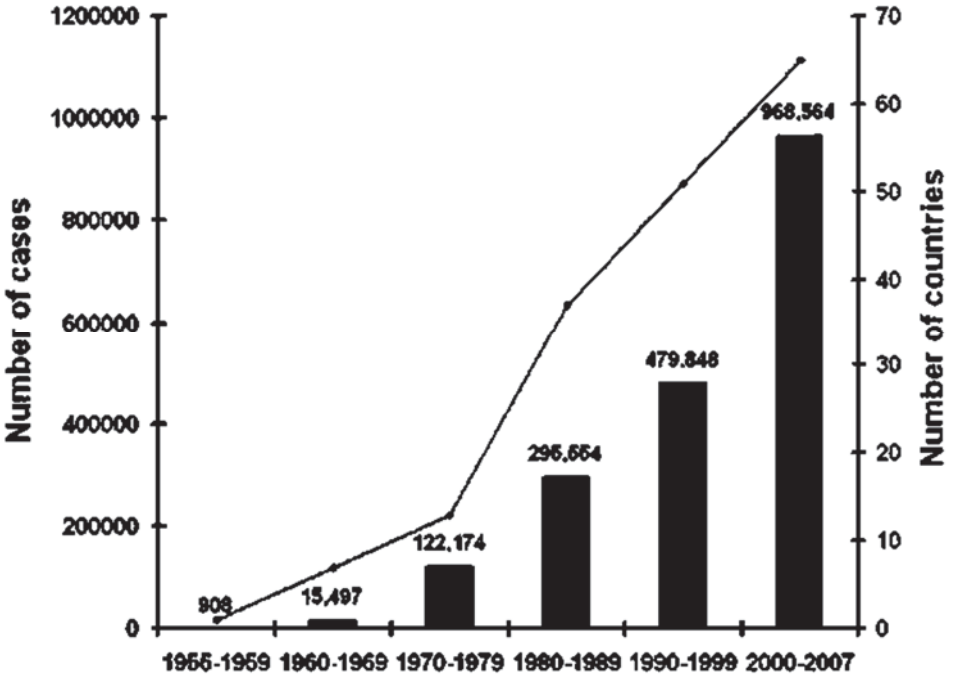

Fig. 3.1

While increased human population and global movement of people and cargo via air travel have undoubtedly assisted the spread of dengue, some scientists have attributed it to the effect of global warming.

Fig. 3.2 shows the global temperature departure (^{0}F) from the long-term average from 1880 to 2010. An additional trend line was plotted for the departure values between 1950 and 2010.

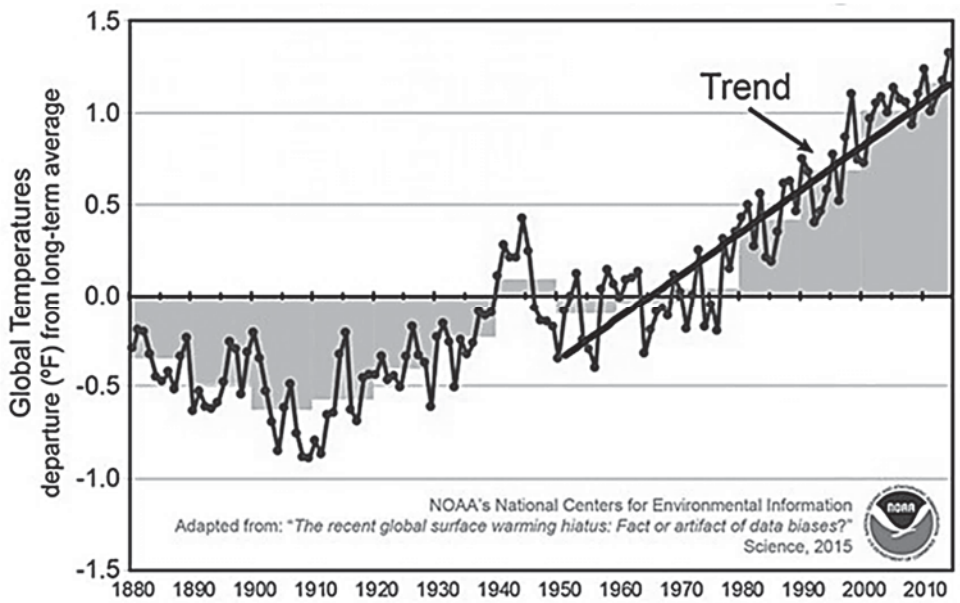

Fig. 3.2

(b) Using evidence from **Fig 3.1** and **Fig. 3.2** and your own knowledge of global warming,

(i) explain how the increase in global annual average number of DF / DHF could be caused by global warming.

[3]

(ii) suggest how global warming can lead to the spread of DF / DHF beyond the tropics into the temperate regions.

[1]

(c) *Wolbachia* is a natural bacterium present in up to 60% of insect species, but it is not usually found in the *Aedes aegypti* mosquito. Research has shown that when introduced into the *Aedes aegypti* mosquito, *Wolbachia* can stop the dengue virus from replicating inside the mosquito and hence prevent transmission to humans.

One possible way in which *Wolbachia* is used to suppress the *Aedes aegypti* mosquito population is through the release of male *Wolbachia-Aedes aegypti* mosquitoes. When these mosquitoes mate with the female wild-type *Aedes aegypti* that do not have *Wolbachia*, those females will lay eggs that do not hatch.

Country **X** released these male *Wolbachia-Aedes aegypti* mosquitoes in several housing estates as a form of vector control. Following three months of releases at the study site, the eggs were collected using ovitraps placed at several sites within the estate. The percentage of unhatched eggs were recorded for both the study and control sites.

(i) State a statistical test that could have been used to determine whether the difference in the mean percentage of unhatched eggs between the study and control sites is significant.

[1]

(ii) Suggest how a suitable control site was selected for the study.

[1]

(iii) A summary of the results is shown in **Table 3**.

Table 3

mean percentage unhatched eggs		probablity
study site	control site	
62.2	15.7	$p < 0.00001$

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

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[2]

[Total: 13]

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) Outline the role of ATP in living organisms using named examples. [13]

(b) Discuss how the survival of species depends on DNA molecules being stable yet not *absolutely* stable. [12]

[Total: 25]

5(a) Outline how variation can arise in any population of living organisms. [13]

(b) Discuss the suggestion that all living organisms on Earth depend on phosphate. [12]

[Total: 25]

Confidential Instructions:

Candidates are advised to spend no more than:

- **60 minutes** on **Question 1**.
- **50 minutes** on **Question 2**.
- **35 minutes** on **Question 3**.

Question 1

i. 15 cm^3 of 0.1% 2,6-dichlorophenol indophenol (DCPIP) solution in a corked, labelled container. Dissolve powder in distilled water.

ii. 5 cm^3 of each of four standard solutions of ascorbic acid prepared as follows:

Dissolve 400 mg of ascorbic acid powder in 100 cm^3 distilled water. Add 15 drops of BDH Universal Indicator solution and adjust the pH to between 7 and 8 by adding 5% sodium hydroxide solution drop by drop. This is **4.0mgcm^{-3}** ascorbic acid solution. Take 50 cm^3 of this solution and to it, add 50cm^3 of distilled water (the **2.0mgcm^{-3}** ascorbic acid solution). Repeat this procedure to obtain **1.0mgcm^{-3}** and **0.5mgcm^{-3}** ascorbic acid. Any variations in the colours of the solution can be ignored, but the pH of the most dilute solution should be checked with indicator paper. If it is found to be below 7 it should be adjusted to pH 7-8 by adding further drops of 5% sodium hydroxide solution.

The solution should be dispensed to students in a corked, **labelled** tubes from which 1cm^3 volumes can be withdrawn.

iii. 5 cm^3 of fresh orange juice. Dispense to students in corked tube labelled orange juice.
iv. Approximately 10cm^3 of **4% glucose solution**; 100cm^3 of **distilled water**, and 50cm^3 of **Benedict's solution** in appropriately labelled, corked containers.
v. Three 2 cm^3 syringe, and two 5 cm^3 syringe; a glass rod; 4 small beakers; 12 test tubes
vi. Test tube rack; Bunsen burner; test tube holder; 250cm^3 beaker; marker; tripod

Question 2

i. A 10 cm length of deeply pigmented purple onion. The plant material should not be allowed to dry out
ii. About 5cm^3 of each of the following in stoppered container labelled appropriately: distilled water, 1 $moldm^{-3}$ sucrose solution and 1 $moldm^{-3}$ [O,T] potassium nitrate solution
iii. 2 clean dry microscope slides and cover slips; 4 droppers; circle of filter paper; pair of fine forceps; fine scissors

Apparatus List

Candidates will require:

Question 1

1 DCPIP
2 Ascorbic acid (AA) labelled 0.5 $mgcm^{-3}$, 1.0 $mgcm^{-3}$, 2.0 $mgcm^{-3}$ **and** 4.0 $mgcm^{-3}$
3 4% glucose
4 Distilled water
5 Benedict's solution
6 Orange juice
7 **12** Test tubes
8 **1** test tube rack
9 **1** test tube holder
10 **3** 2-ml syringes
11 **2** 5-ml syringes
12 **1** Glass rod
13 **1** dropper
14 **4** 50-ml beakers
15 **1** 250ml beaker
16 **1** 500ml beaker
17 **1** stopwatch
18 **1** wire gauze
19 **1** Bunsen burner
20 **1** tripod stand
21 **1** lighter
22 **1** wash bottle labelled as **distill water**
23 **1** pair of goggles
24 **1** permanent marker

Question 2

1 Red onions
2 1M Sucrose
3 1M Potassium nitrate (**oxidising**, **toxic**)
4 **1** Petri Dish
5 **2** microscopic glass slide
6 **2** cover slips
7 **4** droppers
8 **2** filter papers
9 **1** pair of scissors
10 **1** forceps
11 **1** mounted needle

H

NANYANG JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9744/04

Paper 4 Practical

25 August 2017

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	
3	
Total	

This document consists of **14** printed pages and **no** blank page.

[Turn over

Answer **all** the questions.

1 You are required to determine the concentration (in $mgcm^{-3}$) of ascorbic acid (Vitamin C) and glucose in a sample of orange juice.

Proceed as follows:

I. The ascorbic acid test

You have been provided with standard solutions containing **0.5, 1.0, 2.0** and **4.0** $mgcm^{-3}$ of ascorbic acid respectively. These solutions reduce the dye dichlorophenol indophenol (DCPIP) from blue to colourless:

$$\text{DCPIP (blue)} \xrightarrow{\text{ascorbic acid}} \text{reduced DCPIP (colourless)}$$

Using a syringe, place 2 cm^3 of DCPIP solution in a test tube. Place the test tube in a rack. Fill a 2 cm^3 syringe with **4.0 $mgcm^{-3}$** ascorbic acid solution. Add this solution, drop by drop, to the DCPIP solution, stirring gently with a glass rod after each drop. Determine the number of drops needed to decolourise the DCPIP solution.

(a) (i) Note this number in the table 1 below.

Table 1

Concentration of ascorbic acid / $mgcm^{-3}$	number of drops needed to decolourise DCPIP
4.0	
2.0	
1.0	
0.5	
Orange juice	

Repeat this procedure, using fresh samples of DCPIP each time, with the other **three** solutions of ascorbic acid and, finally, with the orange juice with which you have been provided.

(ii) Add these results to the **Table 1**. [2]

(iii) Plot a graph using the data in **Table 1**. [4]

(iv) Use the data you have obtained to determine the ascorbic acid concentration in the sample of orange juice. Explain how you arrive at your answer.

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[2]

II. The ascorbic acid test

You have been provided with a 4% (by mass) solution of glucose, distilled water and Benedict's solution. Using only the apparatus provided, devise and carry out a procedure by which you can make the Benedict's test quantitative in order to determine the glucose concentration (in $mgcm^{-3}$) of orange juice. You should work with five different glucose solutions covering the range from 0.1% to 4% by serial dilution.

Note: In your tests you are advised to use 5 cm^3 of Benedict's solution to 0.5 cm^3 sample of all solutions.

(b) (i) Describe your method and show the results you obtained in a table.

[5]

(ii) Estimate the glucose concentration of the orange juice in $mgcm^{-3}$.

[2]

(iii) Describe two other modifications to your method that would increase confidence in the conclusions and explain how these modifications would achieve this.

1

2

[4]

To a clean test-tube, add 2 cm^3 of DCPIP solution. Using a 2 cm^3 syringe as before, add the same number of drops of 4% glucose solution as you did of the 0.5 $mgcm^{-3}$ ascorbic acid (which you have recorded in **Table 1**).

(c) Note your observations.

[1]

Carry out Benedict's test using the 4.0 $mgcm^{-3}$ ascorbic acid solution.

(d) Note your results.

[1]

(e) State the significance of the procedures which you carried out in **(c)** and **(d)** for the interpretation of your results in **(a)** and **(b)**.

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[3]

[Total: 24]

2 You are required to investigate the effects of sucrose and potassium nitrate (KNO_3) solutions on the cells of the plant material supplied. Peel off several pieces of epidermis from the pigmented areas of the plant tissue, taking care to remove as little as possible of the underlying tissue. Cut the pieces of epidermis so that you have four squares of tissue each approximately 0.5 x 0.5cm. Place these in a dish of distilled water.

Take one piece of epidermis and mount it in distilled water on a microscope slide. Cover with a cover slip. Using your microscope, find an area of the tissue where pigmented cells can be seen clearly, preferably as a single layer of cells.

(a) Describe the distribution of the coloured contents within the cells.

.....

.....

[1]

(b) Mount another piece of epidermis in 1 mol dm^{-3} sucrose solution. Blot off excess water with filter paper before you add the solution.

(i) After about one minute, make a large labelled drawing to show the detailed structure of one epidermal cell which is typical of the most deeply coloured cells which you can see.

[4]

(ii) Describe and explain for the appearance of the cells when placed in 1 mol dm^{-3} sucrose solution.

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[3]

(c) Mount another piece of epidermis in 1 mol dm^{-3} potassium nitrate solution. Immediately observe the detailed structure of a typical pigmented cell.

(i) Compare the appearance of this cell with that drawn in **(b)(i)**.

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[2]

(ii) Suggest a reason for the differences in the appearances of the two cells in the two solutions.

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[2]

(d) Several chemicals are known to affect membrane permeability.

Suggest how ethanol may have an effect on onion epidermis.

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[2]

(e) **Fig. 2** is a stained transverse section through part of the stem of a different plant species. You are not expected to be familiar with this specimen.

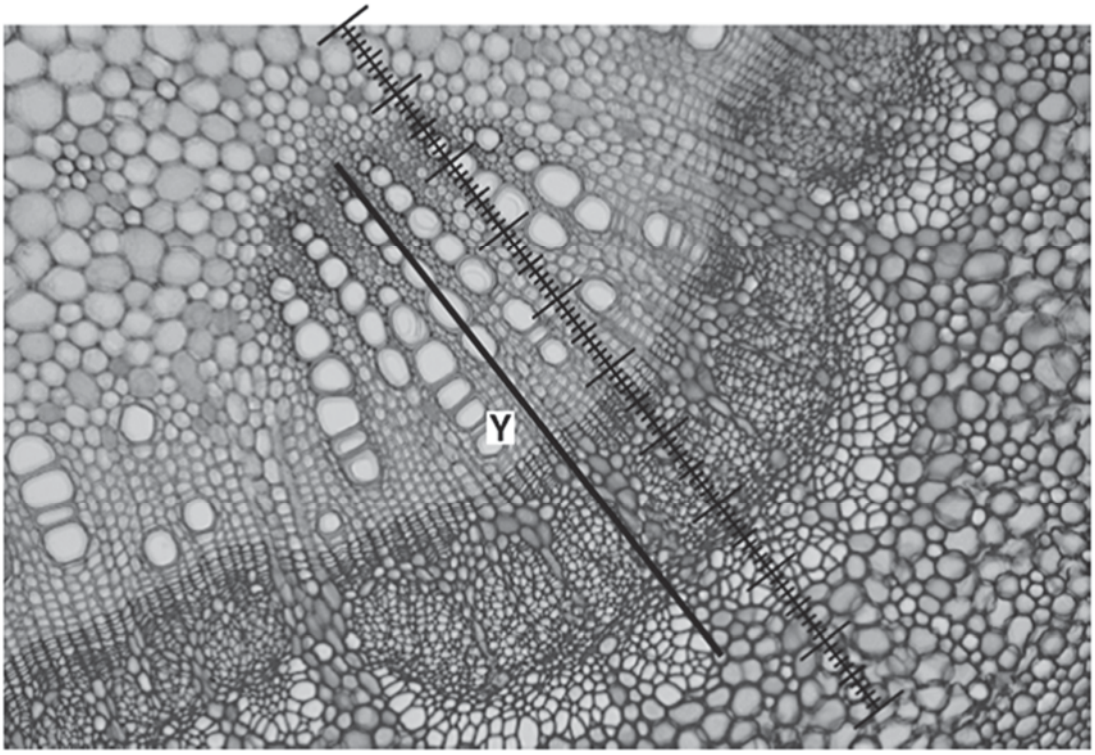


Fig. 2

A student calibrated the eyepiece graticule in a light microscope using a stage micrometer scale so that the actual length of the vascular bundle could be found.
The calibration was: one eyepiece graticule division equal to 11 μm.

Fig. 2 shows a photomicrograph taken using the same microscope with the same lenses as the student. Use the calibration of the eyepiece graticule division and **Fig. 2** to calculate the actual length of the vascular bundle, shown by line **Y**.

You may lose marks if you do not show all the steps in your working and do not use appropriate units.

[3]
[Total:17]

3 All green plants photosynthesise in the light, taking in carbon dioxide and releasing oxygen. They also respire continuously, taking in oxygen and releasing carbon dioxide. The light intensity at which photosynthesis and respiration occur at the same rate, so that there is no net gas exchange, is called the compensation point.

Compensation points can be investigated using hydrogencarbonate indicator solution. This is harmless to living organisms but changes colour over a range of concentrations of carbon dioxide due to changes in pH, as shown in Table 3.1.

Table 3.1

increasing CO_2 in indicator ←			atmospheric CO_2 level			decreasing CO_2 in indicator →		
yellow		orange		red		magenta		purple
pH 7.6	pH 7.8	pH 8.0	pH 8.2	pH 8.4	pH 8.6	pH 8.8	pH 9.0	pH 9.2

Hydrogen carbonate indicator is red in equilibrium with atmospheric air. It changes from red to magenta to deep purple as carbon dioxide concentration decreases. It changes from red to orange to yellow as carbon dioxide concentration increases

Monitoring the colour of hydrogencarbonate indicator solution in sealed vessels containing plant material can show whether carbon dioxide is being taken in or given out.

One factor that can affect the compensation point is whether a leaf is adapted for low light intensities (shade leaf) or high light intensities (sun leaf). Shade leaves would be expected to reach their compensation points at a lower light intensity than sun leaves.

Light intensity = $1/d^2$, where d represents the distance from the light source

Some plants produce both shade and sun leaves depending on where the leaves develop. For example, an aquatic plant can produce sun leaves at the top where they are in direct sunlight and produce shade leaves lower down where light intensity is reduced.

Using this information and your own knowledge, design an experiment to find the light intensity at which shade leaves and sun leaves from an aquatic plant reach their light compensation points.

Comparison of the results would then allow testing of the hypothesis that shade leaves reach their compensation points at a lower light intensity than sun leaves.

You must use:

- hydrogencarbonate indicator solution
- colourimeter and cuvette
- sun and shade leaves from an aquatic plant.

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- bungs
- bench lamp with 60W bulb

Your plan should:

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

[Total:14]

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9744/01

Paper 1 Multiple Choice

26 September 2017

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 and CT on the Answer Sheet in the spaces provided unless this has been done for you.

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.
Calculators may be used.

1 A student has drawn a cell structure as seen using a light microscope.

The magnification of the drawing is ×600.

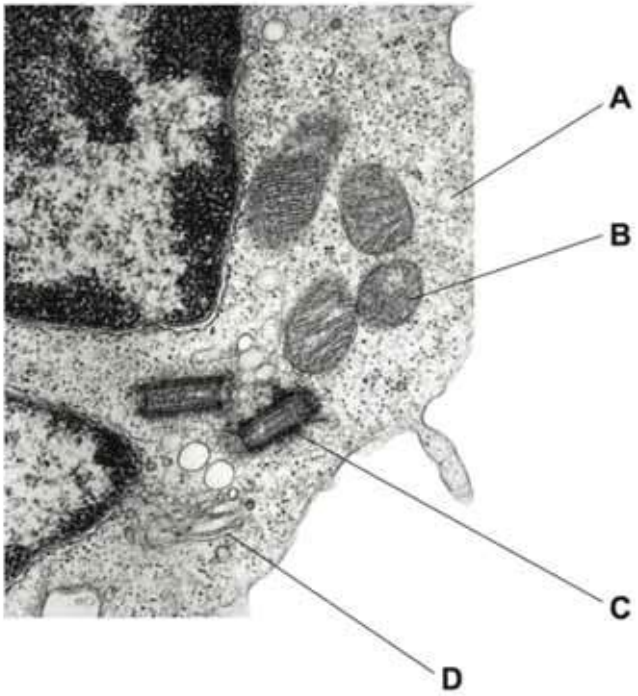
The length of the structure on the drawing is 6mm.

What is the actual length of the cell structure?

A 1×10^{-1} μm **B** 1×10^{0} μm **C** 1×10^{1} μm **D** 1×10^{2} μm

2 The electron micrograph shows part of a eukaryotic cell.

Which of the labelled organelles is a site of protein synthesis? B



3 The table shows some information about four carbohydrate polymers.

polymer	α-1,4 glycosidic bonds	α-1,6 glycosidic bonds	shape of molecule
1	✓	✗	helical
2	✗	✓	branched
3	✓	✓	helical
4	✓	✓	branched

key
✓ = present
✗ = absent

Which two polymers form starch?

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

4 When proteins are mixed with some organic solvents, hydrophobic interactions and hydrogen bonding are changed in the protein molecules.

Which levels of protein structure would be affected? D

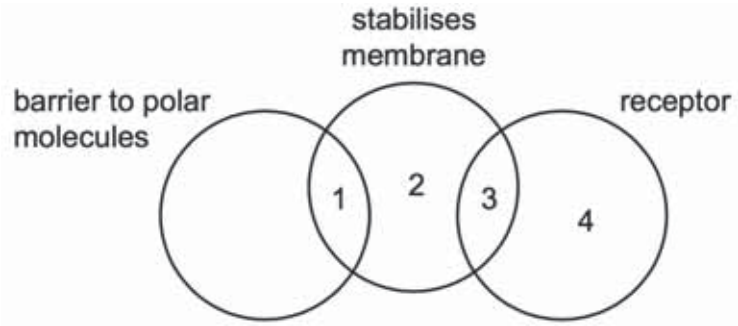
	level of protein structure		
	secondary	tertiary	quaternary
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✓
D	✓	✓	✓

key

✓ = affected

✗ = not affected

5 Which row correctly links molecules in the cell surface membrane with their roles?



	1	2	3	4
A	glycolipid	cholesterol	glycoprotein	phospholipid
B	glycolipid	glycoprotein	phospholipid	cholesterol
C	glycoprotein	phospholipid	cholesterol	glycolipid
D	phospholipid	cholesterol	glycolipid	glycoprotein

6 The table below shows additional information about the enzymes that catalyse some of the reactions in respiration.

enzyme	information
fructose 1,6-bisphosphate aldolase	• four identical subunits • changes to any one of the subunits means that the enzyme cannot function
hexokinase	• one subunit • active site changes shape to enclose the reactants
phosphofructokinase	• four identical subunits • has allosteric sites in addition to an active site
phosphoglucose isomerase	• two identical subunits • has a cytokine function when secreted into the external medium
pyruvate kinase	• four identical subunits • ATP acts as an inhibitor to regulate glycolysis
triosephosphate isomerase	• two identical subunits • each subunit has 14 alpha helices and 8 beta-pleated sheets

A student made the following deductions using the information provided in the table:

- Phosphoglucose isomerase, when secreted, can have a non-catalytic role.
- Only three of the six enzymes display quaternary protein structure.
- The active site of phosphofructokinase will change shape to allow the enzyme to act as a regulator in glycolysis.
- Each enzyme is coded for by one gene.
- The reaction catalysed by hexokinase is an induced-fit mechanism.

How many of the student's deductions are correct and can be supported using the information provided?

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

7 Polypeptide synthesis is based on sequences of three nucleotides, each specific for an amino acid.

Which row shows the correct nucleotide sequences for an amino acid?

	nucleotide sequence of		
	non-transcribed DNA strand	**mRNA codon**	**tRNA anticodon**
A	GGT	CCA	GGU
B	GGG	CCC	CCC
C	CCG	CCG	GGC
D	CCT	CCU	CCU

8 DNA is said to replicate in a semi-conservative way.

Results of Meselson and Stahl's experiments gave overwhelming support to this theory. They used E. coli which has a generation time of 20 minutes.

Here are the steps in their experiment but they are in the wrong order.

P All bacteria contain ^{15}N DNA.
Q All bacteria contain hybrid DNA (^{15}N DNA and ^{14}N DNA).
R Bacteria contain either all ^{14}N DNA or hybrid DNA.
S Bacteria grown in a ^{15}N medium for many generations.
T Bacteria transferred to a ^{14}N medium and sampled every 20 minutes.

Which sequence of letters shows the correct order of the steps in the experiment?

A **P→Q→R→S→T**
B **P→S→T→R→Q**
C **S→P→T→Q→R**
D **S→P→T→R→Q**

9 The table shows the mode of action of two antibacterial drugs that can affect the synthesis of proteins.

antibacterial drug	rifampicin	streptomycin
mode of action	binds to the RNA polymerase	causes errors in translation

If bacteria are treated with both drugs, what will be the immediate effects?

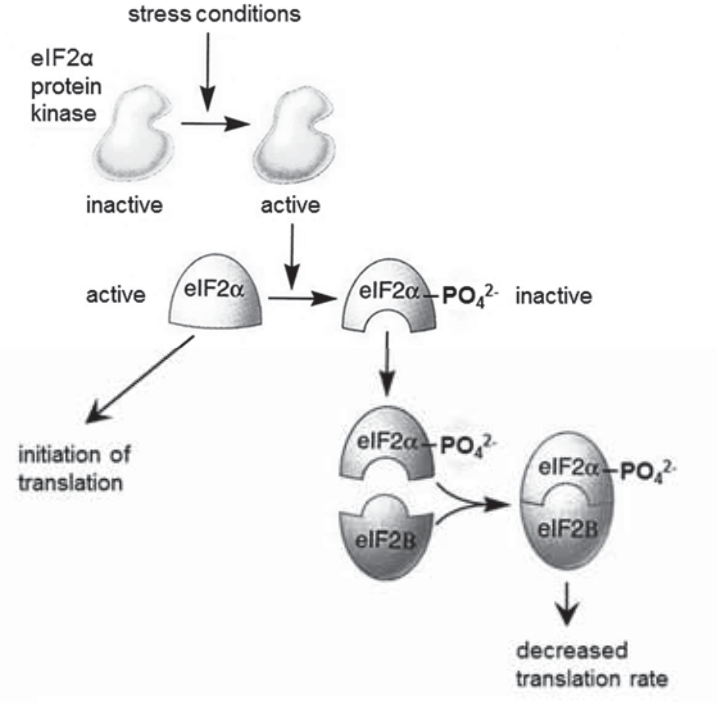
1 Transcription will stop, but faulty proteins may continue to be synthesised.

2 If translation has started, proteins may be faulty.

3 Translation will be inhibited.

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

10 The diagram shows a mechanism by which gene expression is controlled during translation.



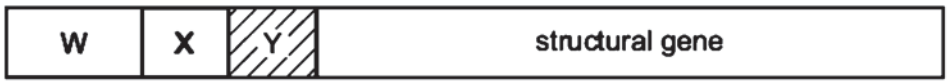
Which statements are correct?

1 Phosphorylation by eIF2α protein kinase changes the conformation of and activates eIF2α.
2 The concentration of eIF2B affects the rate of translation by inhibiting translation initiation.
3 This regulation results in decreased rate of mRNA translation under stress conditions.
4 The eIF2α-eIF2B complex is recognised by proteasomes for selective degradation due to the presence of the phosphate group.

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

11 The diagram represents a length of DNA from a prokaryote that includes a structural gene.

Parts of the length of DNA are labelled **W**, **X** and **Y**. They have different functions in the control of transcription of the structural gene.



What identifies the functions of parts **W**, **X** and **Y**?

	W	X	Y
A	operator	regulator	promoter
B	promoter	regulator	operator
C	regulator	promoter	operator
D	promoter	operator	promoter

12 Which of the following statements concerning lac operon is true?

1 Transcription of lac operon takes place all the time.

2 There is one single mRNA transcribed from the lac operon.

3 There is one start and one stop codon in the mRNA of lac operon.

4 The repressor molecule binds to the operator to turn off lac operon.

A **4** only

B **1** and **3**

C **2** and **4**

D **2**, **3** and **4**

13 Some events that take place during generalised transduction are listed below.

1 Bacterial host DNA is fragmented.
2 Bacterial DNA may be packaged in a phage capsid.
3 Recombination between donor bacterial DNA and recipient bacterial DNA.
4 Phage infects a bacterial cell.
5 Phage DNA and proteins are made.

Which sequence of events is correct?

A 4 1 3 5 2

B 4 1 5 2 3

C 4 5 2 3 1

D 4 5 1 3 2

14 What are the conditions in a human cell just before the cell enters prophase?

	number of molecules of DNA in nucleus	spindle present	nuclear envelope present
A	46	yes	no
B	46	no	yes
C	92	yes	yes
D	92	no	yes

15 The following table shows the chromosome numbers in the hybrids formed between cabbage (*Brassica oleracea*) and radish (*Raphanus sativus*).

type of cell	*no. of chromosomes per cell*
parental cabbage	18
parental radish	18
parental gametes	9
F_1 hybrids	18
F_1 gametes	18
F_2 hybrids	36
F_2 gametes	18
F_3 hybrids	36

During which of the following stages can the occurrence of non-disjunction explain the results?

A formation of the F_1 gametes

B formation of the F_2 gametes

C fusion of the parental gametes

D fusion of the F1 gametes

16 The statements are about genes and proteins, involved in breast cancer.

- The main protein coded by *BRCA1* gene inhibits the growth of breast cancer cells.
- The protein coded by the *p53* gene suppresses tumours.

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

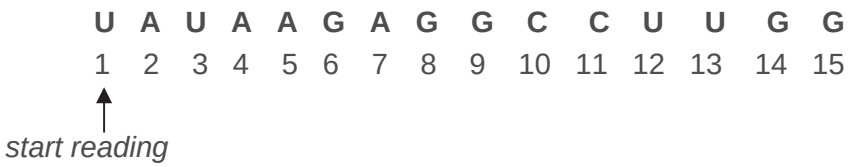
	gene	
	BRCA1	*p53*
A	×	×
B	×	✓
C	✓	×
D	✓	✓

key
✓ = normal active gene
× = mutated gene

17 The following table shows the mRNA codons for six different amino acids.

mRNA codons	amino acid
AAA AAG	lysine
AGA AGG CGG	arginine
GGU GGA GGC GGG	glycine
CCU CCA CCC CCG	proline
UGG	tryptophan
UAU UAC	tyrosine

The base sequence of mRNA coding for part of a polypeptide is shown below.



From the information provided, which of the predictions stated below is **not** true?

A The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.
B The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.
C The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.
D The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

18 Skin colour in onions is controlled by two pairs of alleles **Ss** and **Rr**, which segregate independently. The allele **S** is dominant and must be present to allow development of pigment in the skin. In its absence, the onion skin is white. Allele **R** is dominant and gives red colour; the recessive r gives yellow colour.

What will be the ratio of phenotypes in the offspring of a cross between plants of genotypes **SsRR** and **ssrr**?

A all red
B 1 red : 1 yellow
C 1 red : 1 white
D 1 white : 2 red : 1 yellow

19 Which of the following would cause phenotypic variation among organisms of the same genotype?

A continuous variation within the species

B different varieties of the same species

C exposure to different environments

D mutation

20 A tall, green-stemmed plant with the genotype **TTrr** was crossed to a short, red-stemmed plant with the genotype **ttRR.** The F1 plants were allowed to self-fertilise. A χ^2 test was carried out on the results obtained for the F2 generation.

Part of the table of values for χ^2 is shown.

degrees of freedom	p = 0.5	p = 0.1	p = 0.05	p = 0.01	p = 0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.6	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.36	7.78	9.49	13.28	18.46
5	4.35	9.24	11.07	15.09	20.52

The value of χ^2 in this investigation was 7.6.
What is the probability of this value of χ^2 and do the results fit the expected ratio?

	probability	results fit expected ratio
A	between 0.001 and 0.01	no
B	between 0.01 and 0.05	yes
C	between 0.05 and 0.1	yes
D	between 0.1 and 0.5	no

21 In a series of experiments, actively photosynthesizing plants were supplied with labelled reactants.

1 water containing ^{18}O isotope

2 carbon dioxide containing ^{17}O isotope

3 carbon dioxide containing ^{13}C isotope

Where in the chloroplast would the products of photosynthesis from these reactants be formed?

	^{18}O	^{17}O	^{13}C
A	stroma	stroma	thylakoids
B	stroma	thylakoids	stroma
C	thylakoids	stroma	stroma
D	thylakoids	stroma	thylakoids

22 In an experiment, four tubes were set up as shown in the table below.

tube	contents
1	Glucose + homogenized animal cells
2	Glucose + mitochondria
3	Glucose + cytoplasm lacking organelles
4	Pyruvate + homogenized animal cells

If all other conditions are kept constant, which of the following shows the amount of ATP produced in each tube in **increasing** order?

A 1 – 3 – 4 – 2

B 2 – 3 – 4 – 1

C 4 – 2 – 3 – 1

D 3 – 2 – 1 – 4

23 Which of the following correctly describes the function of second messenger in signal transduction pathway?

A They relay the signal from the outside to the inside of the cell.

B They serve as transcription factors to activate the transcription process.

C They amplify the message by directly phosphorylating the cascades of proteins.

D They relay the message from the inside of the membrane throughout the cytoplasm.

24 Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation? D

A	adaptation of population	→	competition and predation leading to natural selection	→	behavioural isolation	→	sympatric speciation
B	adaptation of population	→	competition and predation leading to natural selection	→	behavioural isolation	→	allopatric speciation
C	competition and predation leading to natural selection	→	geographical isolation	→	adaptation of isolated populations	→	sympatric speciation
D	competition and predation leading to natural selection	→	geographical isolation	→	adaptation of isolated populations	→	allopatric speciation

25 Natural selection acts

A directly on an individual's genetic make-up, thereby changing the survival probability of the individual.

B on individuals by changing their genes so they are better able to adapt to their environment.

C on the structures, physiologies and behaviours expressed by individuals in a population to change allele frequencies.

D on phenotypes of individuals so that they change to adapt to their environment and pass on these changes to their offspring.

26 The map shows the distribution (shaded area) of the lizards belonging to the family Iguanidae. Most species of iguana are found in America but a few species inhabit Madagascar and the islands of Fiji and Tonga (arrows at the bottom centre and bottom right of map).

Two observations were made about the different species of iguana:

1 The various American iguana species shared more similar characteristics among themselves than with those iguana species on the island of Fiji.

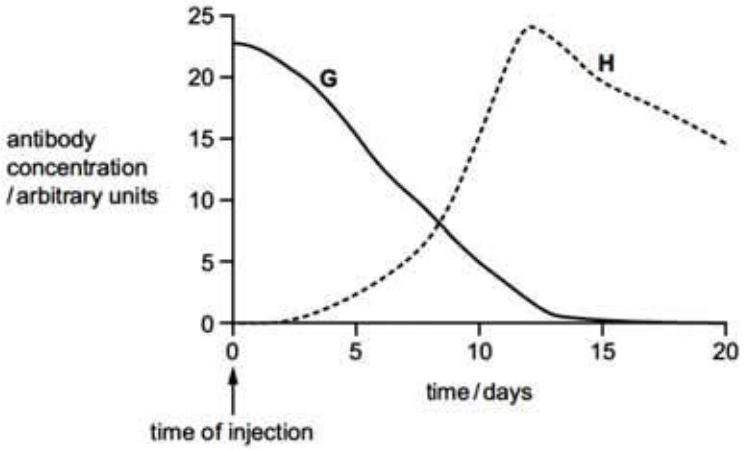
2 The Madagascar iguana species was only distantly related to other lizard species on the African mainland.

Which observation and explanation best support the Darwinian concept of descent with modification?

	Observation	Explanation for the observation
A	1	The various American iguana species had a more recent common ancestor as compared to those iguana species on the island of Fiji that had diverged a longer time ago.
B	1	The various American iguana species shared more similarities among themselves as the degree of homology in their DNA was higher.
C	2	The Madagascan iguana species was reproductively isolated from the lizard species on the African mainland and thus diverged a long time ago.
D	2	The superficial similarities shared among the Madagascan iguana and the lizards on the African mainland were analogous, not homologous.

27 Two people, **G** and **H**, were each given an injection to protect them against a particular pathogen.

One person was injected with antibodies. The other person was injected with a vaccine. The graph shows the concentrations of the antibody against this pathogen in the blood of the two people, **G** and **H**, over a period of 20 days following the injection.



Which row correctly describes the type of immunity shown by **G** and **H**?

	G	H
A	artificial active immunity	artificial passive immunity
B	artificial passive immunity	artificial active immunity
C	natural active immunity	natural passive immunity
D	natural passive immunity	artificial active immunity

28 Which of the statements could describe **both** B-lymphocytes and T-lymphocytes?

1 They contain specific protein receptors in their cell surface membranes.
2 They differentiate into plasma cells.
3 They divide by mitosis.

A 1 and 3

B 1 only

C 2 and 3

D 2 only

29 What is the best definition of the greenhouse effect in the Earth's atmosphere?

A A naturally occurring effect by which shorter wavelength radiation is trapped

B A naturally occurring effect by which longer wavelength radiation is trapped

C An effect of pollution by which shorter wavelength radiation is trapped

D An effect of pollution by which longer wavelength radiation is trapped

30 Global warming caused by the enhanced greenhouse effect is likely to have major consequences for arctic ecosystems. Which of the following are likely to occur in the arctic if the Earth's surface temperature rises?

I Decreased rates of decomposition of detritus
II Increased range of predators from temperate regions
III Increase in numbers of pest species and pathogens

A I and II only

B I and III only

C II and III only

D I, II and III

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9744/02

Paper 2 Structured Questions

September 2017

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 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	14
2	7
3	9
4	11
5	9
6	9
7	12
8	9
9	10
10	10
Total	100

This document consists of **5** printed pages and **1** blank page.

[Turn over

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

1 **Table 1.1** shows some features of four biological molecules that are all polymers.

(a) Complete Table 1.1 by using a tick (✓) to indicate the features that apply to each polymer.

Table 1.1

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				
contains glycosidic bonds				
polymer is branched				
contains nitrogen				
can be found in both animal and plant cells				

[4]

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				✓
contains glycosidic bonds	✓	✓		
polymer is branched	✓			
contains nitrogen			✓	✓
can be found in both animal and plan			✓	✓

(b) **Fig. 1.1** is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate **Fig. 1.1** as part of your answer.

Fig. 1.1

Hydrophilic / polar, phosphate, head / group faces aqueous medium and hydrophobic / non polar, hydrocarbon / fatty acid, tails / chains faces each other / interior of the cell membrane; **R** *if labelled correctly but incorrectly described in the text*

Forming the phospholipid bilayer resulting in partially permeability / ability to act as a barrier to, hydrophilic substances / water soluble substances / polar substances / ions / AW ;

Presence of unsaturated hydrocarbon tails results in kinks, preventing the close packing of phospholipids, thus regulating fluidity of membrane;

[3]

(c) State two components of a cell surface membrane other than phospholipid molecules and describe their function.

max two components, one mark each
one mark for function to match the stated component

Glycolipid / glycoprotein;
Receptors for cell signalling / cell-cell recognition / cell-cell adhesion;

Cholesterol;
Regulate membrane fluidity;

Protein;
Receptor for cell signalling / enzyme / channel protein / carrier protein for facilitated diffusion / active transport

[4]

The fluid mosaic model of membrane structure was first proposed in 1972 by Singer and Nicolson. The model describes in detail how the components of a membrane are organised.

(d) Suggest why 'fluid mosaic' is an appropriate term to use to describe membrane structure.

Fluid refers to phospholipids and proteins being able to move freely within the phospholipid bilayer;

Phospholipids are also being able to move laterally within a layer;

Mosaic – protein molecules are embedded and scattered among the phospholipids;

[3]

[Total: 14]

2 Erythropoietin, also known as EPO, is a large glycoprotein synthesised by specialised cells in the kidney. These cells are very sensitive to changes in oxygen concentration in the blood passing through the kidney and respond to a low oxygen concentration by increasing the synthesis of EPO.

EPO acts at the surface of particular target cells, such as cells in the bone marrow. These bone marrow cells are stimulated to produce red blood cells.

(a) A low oxygen concentration leads to an increase in the quantity of mRNA in the specialised cells in the kidney by activating hypoxia-inducing factors (HIFs) which regulates gene expression at the transcriptional level.

Explain how the activation of HIFs results in an increase in EPO mRNA in the cells.

HIFs are activators which bind to enhancer;
Cause DNA to loop through protein-protein interaction and stabilizes the transcription initiation complex;
Enhance binding of RNA polymerase to promoter to increase rate of transcription;

[3]

(b) All cells of the body are exposed to circulating blood plasma containing EPO, but only particular target cells respond.

(i) Suggest why EPO acts on target cells and not other cells.

Target cells have cell surface receptors specific for EPO;
Binding sites of receptors are complementary in shape to EPO;

[2]

(ii) EPO cannot pass through the cell surface membrane to enter the bone marrow cells. Suggest **one** reason why this is so.

Large protein, therefore cannot pass through the gaps between phospholipids;
Hydrophilic molecule, therefore is repelled / cannot pass through the hydrophobic core of the phospholipid bilayer;
No specific membrane transport protein to transport EPO;

[1]

(c) Red blood cells originate from undifferentiated cells in the bone marrow that are capable of continuous mitotic cell division.

State the name of this type of undifferentiated cell.

stem cell ; A haematopoietic stem cell
treat as neutral adult / non-embryonic / multipotent / stromal

[1]

[Total: 7]

3 **(a)** **Fig. 3.1** is a diagram of an ATP molecule.

Label **Fig. 3.1** to show the components of an ATP molecule.

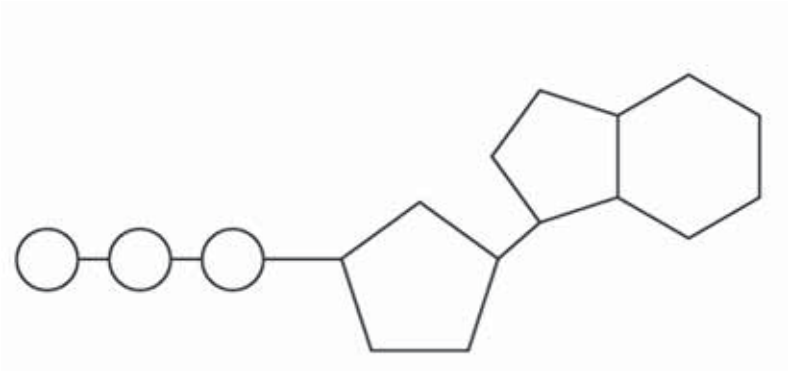


Fig. 3.1

phosphate ;
ribose / pentose sugar ; R deoxyribose
adenine;

labels pointing to correct components

[3]

(b) ATP is used during translation in amino acid activation, when an amino acid becomes attached to its specific tRNA molecule having a particular anticodon. The reaction requires an enzyme called aminoacyl tRNA synthetase.

(i) Explain why a particular amino acid needs to be linked to a specific tRNA molecule.

Anticodon on tRNA binds to codon on mRNA via complementary base pairing;
In order to bring the correct amino acid to the ribosome for translation / give correct sequence of amino acids;
tRNAs bring amino acids, adjacent to each other for peptide bond formation;

[2]

(ii) Explain how the structure of an enzyme such as aminoacyl tRNA synthetase would be altered if the pH of the cytoplasm became too acidic.

Ionic bonds and hydrogen bonds between R groups are disrupted;
Distorts specific 3-dimensional conformation of protein and hence active site is distorted, resulting in denaturation;

[2]

(iii) Aminoacyl tRNA synthetase uses the induced fit mechanism.

Explain the induced fit mechanism.

Active site is not perfectly complementary / not precise fit to substrate (amino acid and tRNA);
Upon binding / formation of bonds with substrate, enzyme changes conformation and active site becomes perfectly complementary / precise fit to substrate;

[2]

[Total: 9]

4 *Morbillivirus* causes measles. The structure of *Morbillivirus* is shown in **Fig. 4.1**.

Haemagglutinin (H) and fusion protein (F) are glycoproteins embedded in the viral envelope.

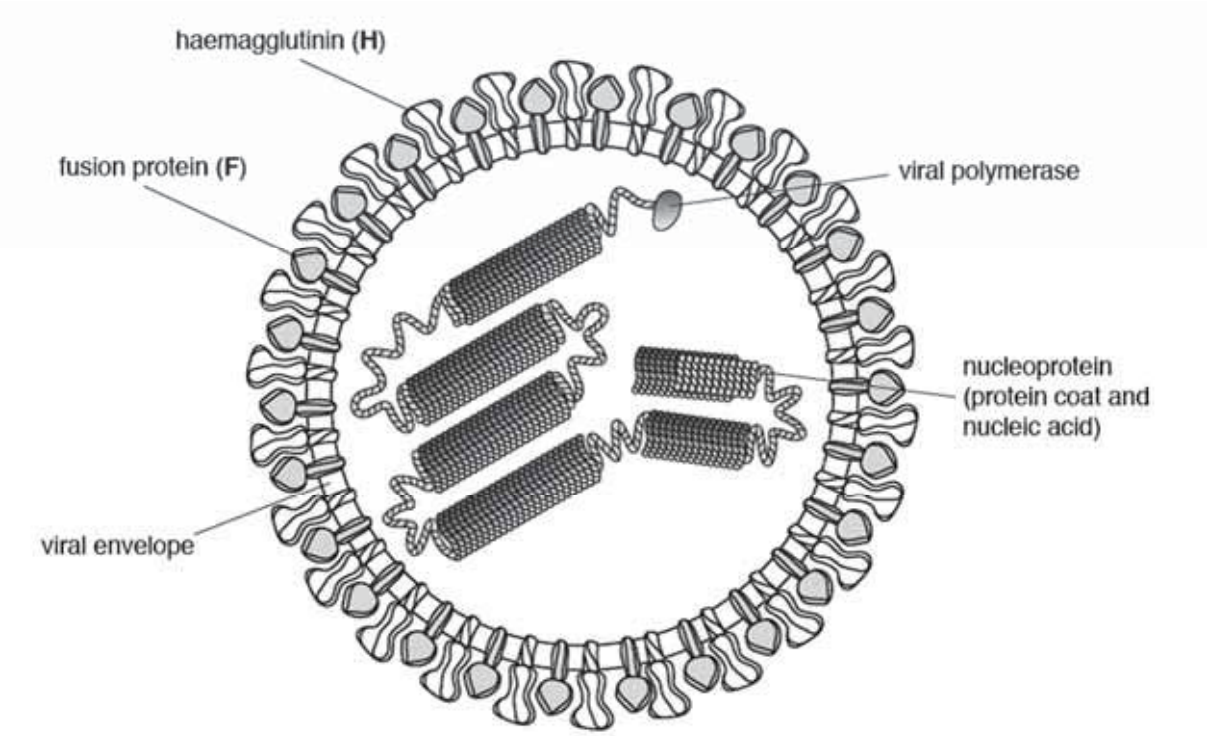


Fig. 4.1

Morbillivirus only infects cells that have a membrane glycoprotein known as signalling lymphocyte activation molecule (SLAM).

When *Morbillivirus* infects a cell, **H** acts before **F**. After the virus binds to the host cell, only the nucleoprotein with the viral polymerase enters the host cell and the virus is replicated.

Morbillivirus replicates its genetic material in the same manner as influenza virus.

New viral particles leave the host cell by budding from the cell surface membrane of the cell. This forms the main part of their envelope.

(a) List two ways in which the structure of *Morbillivirus*:

(i) is similar to HIV

Both have viral envelope (studded with glycoprotein);

Both contains RNA as nucleic acid;

Both contain fusion protein on the viral envelope;

[2]

(ii) differs from the HIV

1 copy of genome vs 2 copies of genome;

Negative sense RNA genome vs Positive sense RNA genome

viral polymerase vs protease + reverse transcriptase + integrase

haemagglutinin vs gp120 embedded in viral envelope;

conical capsid / enclose entire genome vs nucleoprotein

[2]

(b) With reference to **Fig. 4.1** and the information provided,

(i) suggest how *Morbillivirus* infects a cell with SLAM glycoproteins so that only nucleoprotein and viral polymerase enter.

haemagglutinin / H / (viral) glycoprotein, binds to / fits into / complementary to, SLAM / receptor ;

viral envelope fuses with cell surface membrane;

[2]

(ii) suggest the role of viral polymerase in *Morbillivirus*.

replication of RNA / to make copies of genes / AW ;

convert negative sense RNA to positive sense RNA / production of mRNA ;

detail ; e.g. to make viral proteins ;

[3]

(c) Measles has only one serotype. Within this serotype, there are 24 genotypes recognised to date.

Describe how these 24 genotypes could have arisen.

by antigenic drift / mutation

RNA genome mutation due to lack of proof reading by viral polymerase

(Change in haemaglutinin molecule greater infectivity)

[2]

[Total: 11]

5 An *Allium cepa* root was cut into ten transverse sections at different distances from the tip. The sections were stained and viewed under the microscope. The number of cells in mitosis were counted in each section and the results were used to determine the mitotic index.

This is calculated as follows:

$$\text{mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}}$$

Fig. 5.1 shows the mitotic index for the ten sections.

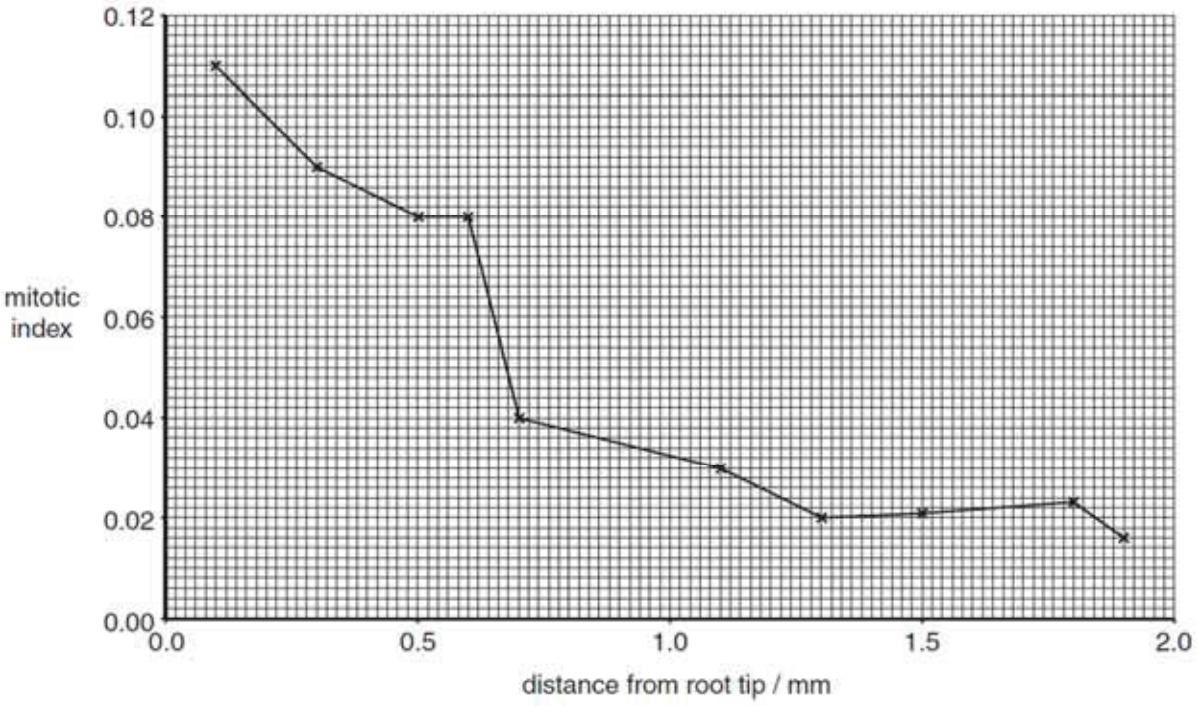


Fig. 5.1

(a) Using the information in **Fig. 5.1**, describe how the mitotic index changes along the length of the root.

MI decrease from 0.11 to 0.016, as distance from tip increases/from 0.1 to1.9mm;

Other description with ref to quoted data;

[2]

(b) Explain how the events in the mitotic cell cycle ensure that all the cells in the root are genetically identical.

semi-conservative DNA replication during, interphase/S phase;

During metaphase, centromeres of chromosomes align at the metaphase plate;

During anaphase, genetically identical sister chromatids are separated/move to opposite poles/go into

separate cells";

After cytokinesis, new cells have same number, and kind of chromosomes/AW e.g. same,genes/DNA/chromosomes as parents;

[3]

(c) 2 genes, **A/a** and **B/b** are linked on the same pair of homologous chromosomes in *Allium cepa*, as shown in **Fig. 5.2**.

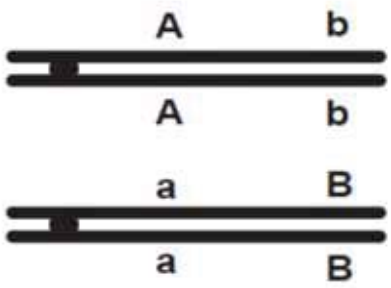
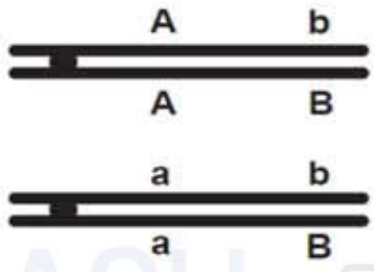


Fig. 5.2

With reference to **Fig. 5.2**,

(i) draw a diagram to show the effect of crossing-over between the homologous chromosomes.



Cross over in between two gene loci;

Outcome;

[2]

(ii) state the effect of linkage and crossing-over on the proportions of gametes with different genotypes that are produced.

large number of, parental types / Ab and aB and small number of, recombinant types / AB and ab;

more recombinants further loci are apart / ora;

[2]

[Total: 9]

6 *CFTR*, the cystic fibrosis (CF) gene, encodes for the CFTR protein that plays an essential role in anion regulation and tissue homeostasis of various epithelia. In the gastrointestinal (GI) tract CFTR promotes chloride and bicarbonate secretion, playing an essential role in ion and acid-base homeostasis.

Gene mutations responsible for cystic fibrosis can be classified into 6 different classes.

- **Class I** mutations can result from nonsense and frame-shift mutations, as well as mRNA splicing defects.
- **Class III and IV** mutations are typified by aberrant channel function, rather than reduced quantities of CFTR.

(a) Explain how **Class I** mutations result in a reduction in the quantity of functional CFTR protein.

Nonsense mutation results in a truncated protein being formed, which will not be able to fold into a functional protein ;

Frame-shift mutation results in a extensive change in amino acid sequence, resulting in a non-functional protein being formed ;

mRNA splicing defects will not result in a mature mRNA formed/does not have the correct continuous coding sequence, hence resulting in a non-functional protein being formed ;

Only one normal allele coding for functional protein instead of two;

[max 2 marks]

[2]

(b) Explain how **Class III** and **IV** mutations result in aberrant channel function.

Substitution of a single nucleotide in the CFTR gene, results in change in amino acid in the polypeptide chain;

Different interactions between different R groups, result in change in specific 3-dimensional conformation of protein, hence loss of function;

[2]

CFTR, has been identified as a candidate driver gene for colorectal cancer (CRC) in mice and humans. Further, recent epidemiological and clinical studies indicate that CF patients are at high risk for developing tumours in the colon. Investigations suggest that *CFTR* is a ***tumour suppressor gene*** in the intestinal tract as *CFTR* mutant mice developed significantly more tumours in the colon and the entire small intestine.

(c) Explain why a mutation in the tumour suppressor gene, such as the *CFTR* gene, may lead to significantly more tumours in mice.

ref to normal function of TSG;

LOF mutation;

In both alleles of the gene such that no functional protein is produced;

resulted in loss of control of cell cycle/ uncontrolled proliferation of cells leading to tumour formation;

[3]

(d) Suggest how tumours can eventually become malignant, leading to cancer.

ref to angiogenesis/ blood vessels supplying nutrients and oxygen to tumour;

ref to tissue invasion / metastasis/ loss of density dependent inhibition anchorage thus cells break away to establish themselves in other organs/ tissues;

[2]

[Total: 9]

7 **(a)** Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, I^A, I^B and I^o. Alleles I^A and I^B are codominant and I^o is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

I^A allele codes for A antigen and I^B allele codes for B antigen;

Individual with genotype I^AI^B will have both A and B antigens and therefore, AB blood group;

Phenotype of heterozygote different from either homozygote whereby I^AI^A gives A blood group and I^BI^B gives B blood group;

[3]

(b) In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

son receives Y chromosome from father / did not inherit X chromosome containing haemophilia allele from father ;

father will pass haemophilia allele to daughter(s) ;

daughter may pass allele to, her son / his grandson ; accept on diagram

[3]

(c) A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black ($\mathbf{C^B}$) and splashed-white ($\mathbf{C^W}$). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

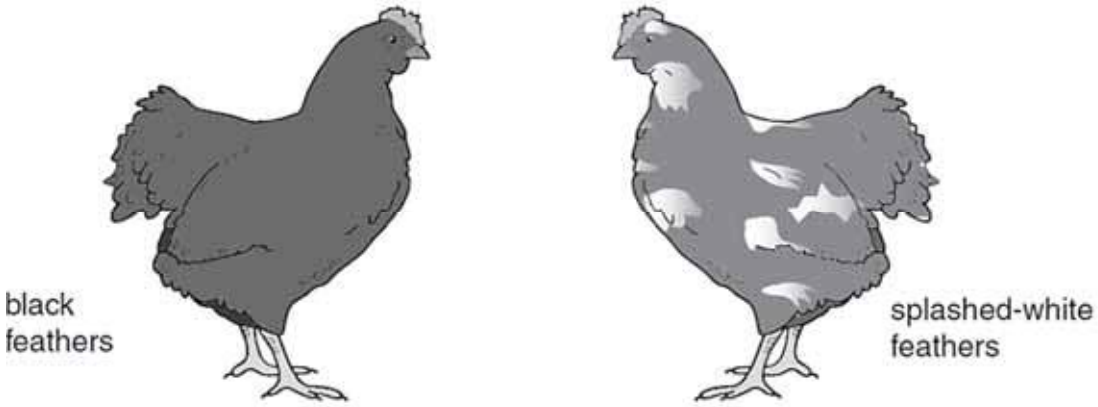


Fig. 7.1

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers ($\mathbf{X^A}$) is dominant to the allele for nonbarred feathers ($\mathbf{X^a}$).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.

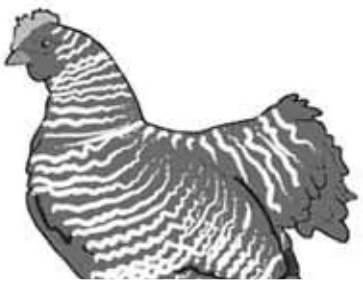


Fig. 7.2

(i) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above draw a genetic diagram to show this cross.

parents' phenotype	male, black, non-barred feathers.	female, splashed-white, barred feathers.
genotype		
gametes		
offspring genotypes		
phenotypes	male, blue, barred feathers.	female, blue, non-barred feathers.

[5]

(c) (i) (male) $C^BC^BX^aX^a$; x (female) $C^WC^WX^AY$;

(gametes) C^BX^a C^WX^A or C^WY ;

$C^BC^WX^AX^a$; (male, blue, barred)

$C^BC^WX^aY$; (female, blue, non-barred)

accept other symbols but only with key
if male XY and female XX then mark gametes and offspring genotypes to max 2
if other symbols used but no key then mark to max 2 [5]

1 mark for parental genotype;
1 mark for gametes;
1 mark for offspring genotype and matching;

[3]

(ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

with non-barred female ;

if all offspring barred, must be X^AX^A / homozygous ;

if some offspring non-barred, must be X^AX^A / heterozygous ;

[3]

[Total: 12]

8 Heart muscle cells and epidermal cells were extracted from Chinese hamsters. The cells were lysed and the mitochondria and cytosol were isolated. The mitochondria and cytosol were then mixed and re-suspended in a culture of essential nutrients. This suspension system was used to study the process of cellular respiration.

At time 0, glucose was added to the system. At Time X, Digitonin, a detergent which disrupts membranes was introduced to the suspension system. A probe was used to measure the concentrations of ATP as well as the pH level in the mitochondria.

The experimental results are recorded in the graphs shown. **Fig. 8.1** shows the rate of ATP production for heart muscle cells and epidermal cells. **Fig. 8.2** shows the pH level of the mitochondria in both heart muscle and epidermal cells.

Fig. 8.1

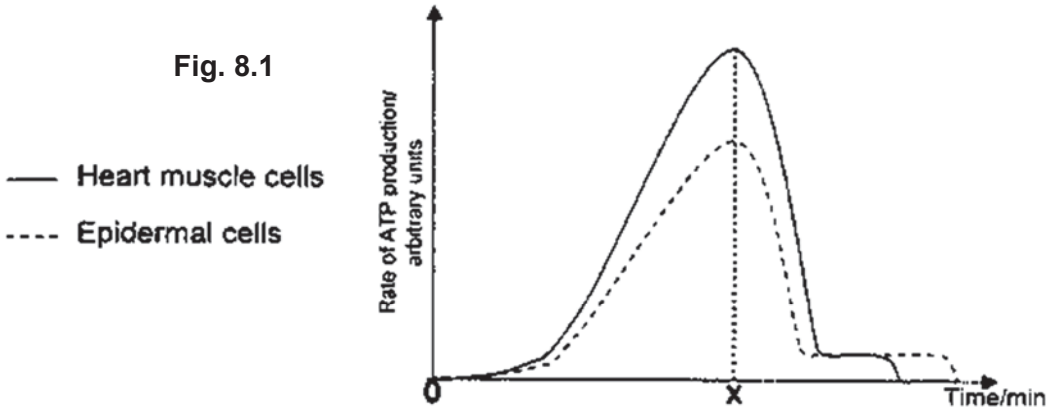
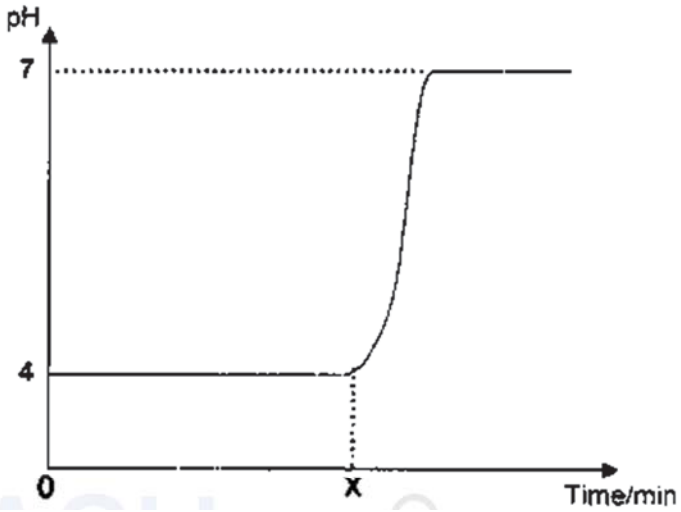


Fig. 8.2



(a) Account for the difference in the level of ATP production in both tissues after glucose was added.

Heart cells produce a higher level of ATP as it contains more mitochondria than epidermal cells;

[1]

(b) With reference to **Fig. 8.1**, explain the changes in ATP production over time for the heart muscle cell suspension.

2 marks max for the first 3 marking points

High energy electrons from reduced coenzymes are passed down a series of electron carriers on the ETC, each with an energy level lower than the one preceding it;

Energy from the flow of electrons is used to actively pump protons from matrix to intermembrane space, through conformational change of proteins in ETC;

Rate of ATP production increases with time before addition of X due to protons diffuse down the electrochemical proton gradient back into mitochondrial matrix through ATP synthase/ stalked particles, synthesizing ATP from ADP and Pi;

Ref to effect resulting from the membrane damage e.g. no ETC / ATP synthase / electrochemical gradient etc

Initial lag in ATP production because glycolysis is occurring to produce 2 ATP per glucose by substrate level phosphorylation;

OR

Rate of ATP production levels off because glycolysis can still occur and decreases to zero when glucose is used up;

[3]

(c) With reference to **Fig. 8.2**, state which region of the mitochondrion the pH probe was measuring. Explain your conclusion.

Intermembrane space;

Ref to pH4 + protons are actively pumped from matrix into intermembrane space;

[2]

(d) Suggest why cytosol was used to re-suspend the mitochondria.

Enzymes involved in glycolysis are present in the cytosol;

[1]

(e) From your biological knowledge, explain the adaptation of the double membrane for its role in the production of energy.

Membrane is impermeable to protons, creating electrochemical proton gradient across the inner mitochondrial membrane;

Highly folded inner membrane increase surface area for stalked particles containing ATP synthase and electron carriers to be embedded;

Compartmentalisation so that reactions can occur in different locations (ref. to provision of optimal conditions for enzymes such as that for Krebs' Cycle to work);

[2]

[Total: 9]

9 The camel family, Camelidae, are well-known for their ability to survive the hot and dry conditions of the desert, but studies have found that they once thrived in colder climates. A recent finding by a group of scientists unearthed fossilised remains of a giant species of camel in North America. This giant species of camel is closely-related to the one-humped Dromedary camel now found in Africa (**Fig. 9.1**). The distinctive humps of both camels are fat stores.

Dromedary camel **Giant camel**

Fig. 9.1

(a) Suggest how the presence of hump in both the ancestral Giant camel and modern-day Dromedary camel allow them to adapt to their respective habitats.

Ancestral Giant camel in the cold Arctic: Fats in hump used as food store to release energy in the form of ATP / Fats used to keep the camels warm as insulator of heat ;

Dromedary camel in the desert: Fats in hump mainly used to release metabolic water when oxidised in respiration ;

[2]

Until only about two or three million years ago, the Camelids were largely confined within North America. Following the formation of the Bering Land Bridge and the Isthmus of Panama, camels migrated from North America to Asia and South America respectively. Today, camels are no longer found in North America.

Three modern-day groups of species survive today:

- the one-hump Dromedary camel of north Africa and southwest Asia,
- the two-hump Bactrian camel of central Asia and
- the South American Camelids group which has diverged into four species: llamas, alpacas, guanacos, and vicuñas.

Fig. 9.2 shows the distribution of modern-day camels in the world.

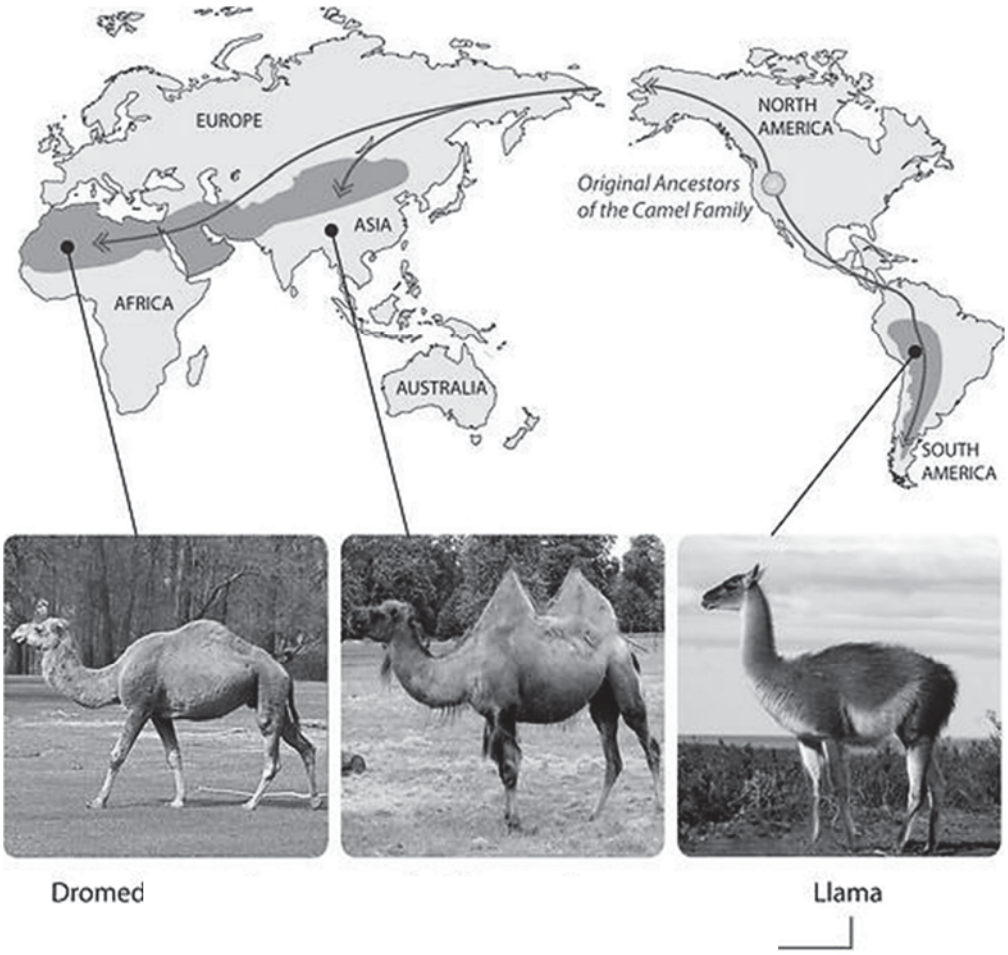


Fig. 9.2

The various species of the modern-day camels evolved from the ancestral population in North America.

(b) With reference to **Fig. 9.2**, describe how natural selection could have occurred to give rise to the various species of camels in the world today.

Different environments resulting in different selection pressures;

By natural selection, individuals who are better adapted survive till maturity and produce offspring who inherit the beneficial / favourable / advantageous alleles;

As North America and Asia are not continuous/ separated by sea, there is geographical isolation /

There is behavioural / physiological isolation resulting in two populations arising in North America and South America;

Isolation in different continents results in prevention of interbreeding and hence there is no gene flow between sub-populations and over time (and space) evolved into separate species due to accumulation in genetic differences;

when reproductive isolation/ of two or more populations of the same species occurs/ when two populations are no longer able to interbreed to form fertile and viable offspring, new species arise;

2 marks for natural selection + 2 marks for speciation

[4]

(c) The Arabian camels in Australia typically have sand coat colour. However, there is a small percentage of camels which have albino coat. It is known that the albino coat is a recessive condition and it reduces the life-span of the camel. The population of the sand coat and albino coat camels in a region was documented.

(i) Explain why population is considered the smallest unit of evolution.

Population refers to a group of interbreeding individuals of the same species;

Evolution is the genetic changes / change in allelic frequency that occur in the population of organisms through time, leading to differences amongst them.

But a population can have variation in traits / characteristics and individual cannot acquire variation;

thus be subjected to forces of natural selection, and can undergo all the changes in genotypes and phenotypes associated with evolutionary change.

[2]

(ii) Explain whether it is likely that the albino camel will disappear completely from the population over time. Assume there is no introduction of new albino camels into the population.

Unlikely;

Reference to diploidy where recessive allele is protected in the heterozygote condition (i.e. heterozygote protection) ;

When two heterozygote interbreed, there is 25% chance of producing a homozygote recessive camel (gg) showing the albino coat [1/2]

[2]

[Total: 10]

10 (a) The infectious disease tuberculosis (TB) is caused by a bacterium.

Each of the descriptions **A** to **C** describes a cell structure found in prokaryotic cells **and** in plant cells.

For each of the descriptions **A** to **C**:

- name the cell structure described
- state **one** difference in this structure between a prokaryotic cell and a plant cell.

A the site of polypeptide synthesis

cell structure ribosomes

difference 70S ribosomes vs 80S ribosome

B the genetic material of the cell

cell structure DNA/ chromosome

difference circular DNA vs linear DNA / no histone proteins vs histone proteins / not surrounded by nuclear envelope vs surrounded by nuclear envelope

C the structure that provides a rigid shape to the cell and prevents osmotic lysis

cell structure cell wall

difference peptidoglycan cell wall vs cellulose cell wall

[3]

(b) Describe how TB is transmitted from an infected person to an uninfected person.

1 infected person, coughs / sneezes / breathes out/AW, droplets containing, bacteria/ pathogen/ M. tuberculosis ;

2 aerosol / airborne droplets / droplets in air / moist air, inhaled/ inspired/ breathed in (by uninfected person) ;

[2]

(c) Outline how the use of vaccine can give protection against diseases such as tuberculosis.

1 vaccine contains (bacterial) antigen(s);

2 During primary immune response, naïve B-lymphocytes @ B cells are activated and formation of plasma cells that secrete antibody / immunoglobulin (against TB antigens)/ antitoxins;

3 T-helper lymphocytes secrete cytokine and (cytokine) increases humoral response / stimulates cytotoxic T cells / stimulates macrophages;

4 memory B cell production;

5 During secondary (immune) response, response on further infection is faster;

6 memory B cell quickly undergo clonal expansion and higher levels of antibodies produced (during further infection);

7 active artificial immunity (against cholera);

8 AVP e.g. idea of specific antibody against each of the different vaccine antigens;

[5]

[Total: 10]

H

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 2017**

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 in the spaces provided on the separate answer paper provided.

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	**17**
2	**20**
3	**13**
Section B	
Total	

This document consists of **18** printed pages and **no** blank page.

[Turn over

Section A

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

1 About one third of the injuries to racehorses involve tendon damage. In 2006, bone marrow stem cells were taken from injured racehorses and cultured so that they divided many times by mitosis. Each horse's cells were then injected into its damaged tendons. 80% of the treated horses returned to racing, compared with 30% of those treated conventionally.

(a) Adult stem cells such as these are described as multipotent.
Explain what is meant by the term multipotent.

multipotent cells can differentiate into a limited number of cell types (but not into whole organism) ;

[1]

(b) In these treatment procedures, the bone marrow stem cells are stimulated to increase their rates of cell division so as to produce large enough numbers of cells to be injected into the horses.
Using your knowledge of cell signalling, describe how the rate of mitosis can be controlled.

Ref to ligand-receptor interaction:
external growth factors (first messengers) / mitogens / cytokines / signal molecules/ AW ;
receptors on cell (surface) membrane ;

Ref to signal transduction:
activate kinases, kinases phosphorylate enzymes (and alter their activity) ;
ref to idea of a phosphorylation cascade leading to signal amplification;

Ref to response:
activate, transcription factors / promoters ;
increase production of cyclins/ proteins controlling cell cycle/ expression of POGs ;
cyclins / kinases control stages of, cell cycle / mitosis ;

A ref to checkpoints during cell cycle

[4]

(c) Suggest how it is possible that bone marrow stem cells could differentiate into the range of cell types needed for repairing injuries.

Compulsory point:
stem cells are genetically identical and contains the complete genome/ all the genes;
(example of cell types required to rebuild tendon), blood vessel cells, connective tissue cells, fibroblasts;

different (sets) genes are turned on in different cell types/ different genes will be expressed in different cell types/ under different conditions;

gene expression alters the possibility of expression of further genes;
reference to influence from microenvironment/ influence of signals from adjoining cells as well as from distant cells;

[2]

Like most mammals, T cell (T lymphocytes) in horses differentiate inside the thymus gland. During T cell differentiation, specific cell surface proteins known as CD proteins are produced and inserted into the cell surface membrane.

Fig. 1.1 shows the stages involved in the synthesis of a CD protein in a T cell.

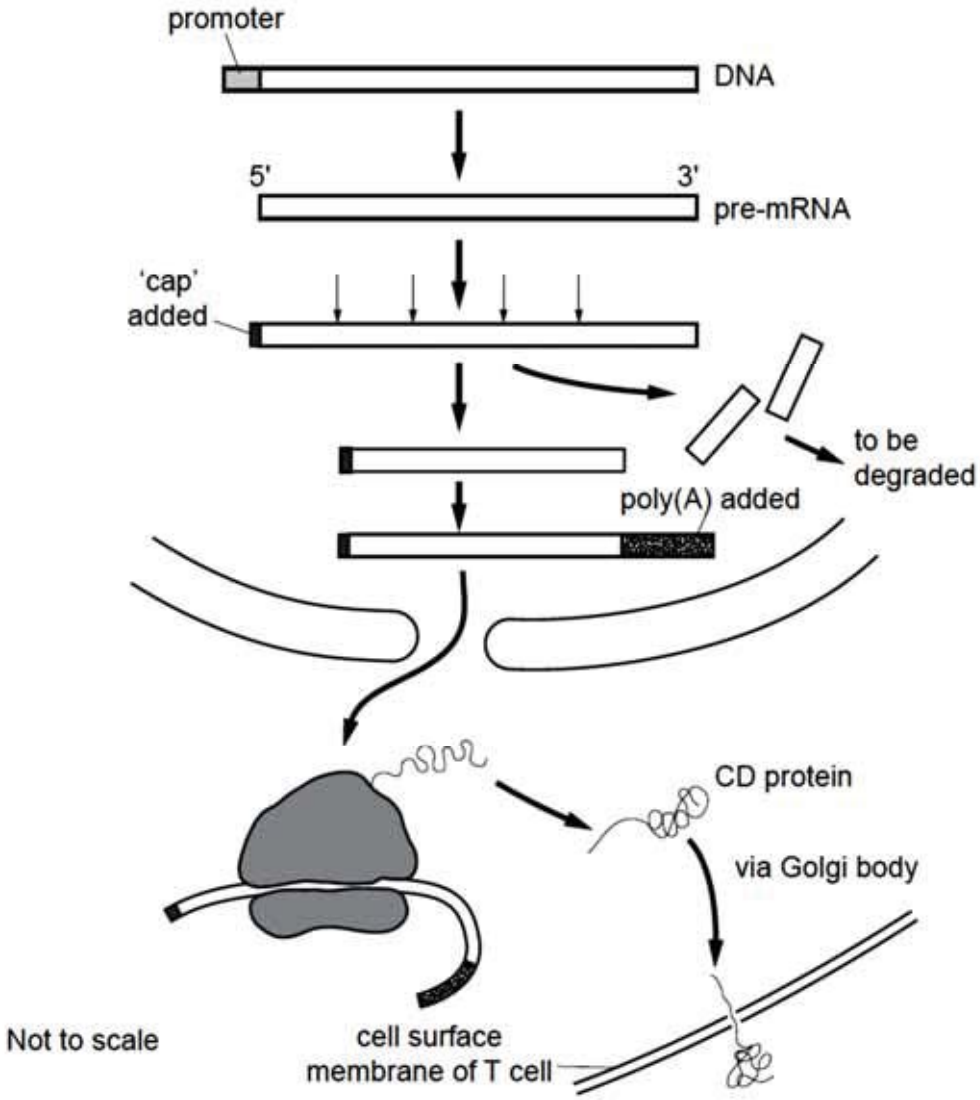


Fig. 1.1

(d) Explain the function of the promoter region of the DNA.

RNA polymerase binds to promoter region ;
transcription factors also required ;
starts transcription ;
upstream of gene to be transcribed ;

ref to at 5' end ;

[2]

(e) Using **Fig. 1.1** as a guide, describe the events that occur in the nucleus of the T cell to produce a pre-mRNA encoding a CD protein.

transcription/ assembly of nucleotides/ nucleoside triphosphates ;
RNA polymerase ;
base pairing / e.g. (A – T / U – A / C – G / G – C) ;
phosphodiester bonds ;

[3]

(f) Explain why the cuts made in pre-mRNA are necessary for the T cell to produce a functional CD protein.

introns are non coding
have to be excised, remaining exons are ligated to produce a continuous coding sequence/ only exons are to be translated;
ref to correct amino acid sequence that can fold to give the specific 3D structure;

[3]

(g) Explain the functions for the 'cap' and the poly-A region attached to the mRNA.

prevent breakdown of, mRNA / exons ;
directs mRNA to ribosome / AW ;

cap identifies 'start' of mRNA ;
assembly point for small and large subunits of ribosomes ;
AVP ; e.g. distinguished from viral RNA / identifies host RNA

[2]
[Total: 17]

2 Lactate dehydrogenase Lactate dehydrogenase (LDH) is an enzyme found in many organisms. Within the same organism, it can be found in different forms, called isoenzymes. The isoenzymes are structurally different but all catalyse the same reaction.

(a) **Fig. 2.1** shows a reaction catalysed by lactate dehydrogenase that occurs during anaerobic respiration in muscle tissue.

(i) Complete **Fig. 2.1** by identifying the compounds **A**, **B** and **C**.

A: pyruvate;

B: reduced NAD / NADH + H+

C: oxidised NAD / NAD+
B and C one mark

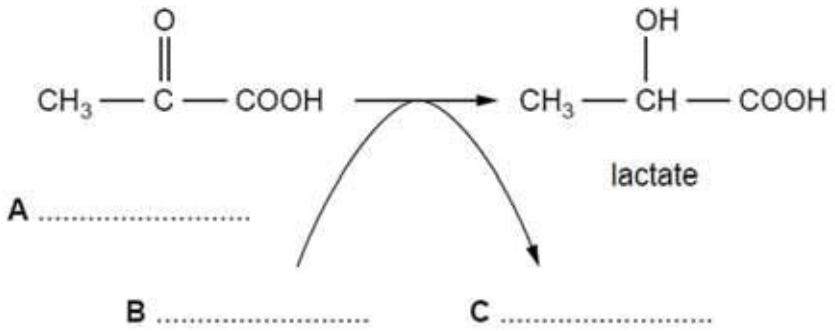


Fig. 2.1

[2]

(ii) State where in the cell this reaction takes place.

Cytoplasm / cytosol;

[1]

(iii) Explain the importance of this reaction in mammalian muscle tissue.

regenerates NAD and allows glycolysis to continue (during oxygen deficit) ;
allows ATP production (to continue) for (muscle) contraction ;

accept details of ATP involvement in contraction:
e.g. temporary storage of hydrogen/ hydrogen transferred prevents accumulation of reduced NAD/AW
e.g. lactate transported areas with (more) oxygen (for oxidation)
e.g. lactate prevents damage to muscles by overexertion/AW

[3]

Lactate dehydrogenase isoenzymes are globular proteins, each consisting of four polypeptides.

(b) Explain how the structure of an enzyme, such as lactate dehydrogenase is suited to its role.

Tertiary/ quaternary structure held in place by, bonds /interactions between R groups ;
Forming specific 3D structure with active site complementary to substrate;
Ref to active site being complementary in terms of shape, size, charged, orientation;
E-S complex formation lowers activation energy for catalysis;
(Globular) protein with hydrophilic amino acids on the exterior allowing protein to be soluble;
(soluble), reactions in aqueous medium/ ref to transport of enzyme;

[4]

Lactate dehydrogenase isoenzymes are made up of two types of polypeptide: polypeptide M, which is coded for by the *LDH-A* gene and polypeptide H, which is coded for by the *LDH-B* gene.

Table 2.1 shows the composition of different human lactate dehydrogenase isoenzymes and examples of tissues and organs where each can be found.

Table 2.1

isoenzyme	polypeptide composition of enzyme	example of isoenzyme location
LDH-1	HHHH	heart red blood cells
LDH-2	HHHM	heart red blood cells
LDH-3	HHMM	brain lungs
LDH-4	HMMM	kidneys placenta
LDH-5	MMMM	liver skeletal muscles

(c) With reference to **Table 2.1,** suggest how red blood cells of the same individual can produce different isoenzymes.

genome of red blood cell contains both genes ;
control of assembly of transcribed polypeptides to produce different proteins/ description of the different chains that make up the different protein;
different R group interactions between the different polypeptide chains, resulting in different quarternary structure / specific 3-dimensional structure

[2]

Besides lactate dehydrogenase, another extensively studied protein which is also involved in respiration is cytochrome c. Cytochrome c plays an important role in oxidative phosphorylation as an electron carrier of the electron transport chain.

(d) **Fig. 2.2** shows the amino acid sequence of a section of the cytochrome c polypeptide chain retrieved from a human and the other species. The dashes shown in the figure indicates that the amino acid present at the position is identical to that of the human species.

Molecular homology of cytochrome c																						
		1					6				10				14			17	18		20		
Human		Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Ile	Met	Lys	Cys	Ser	Gln	Cys	His	Thr	Val	Glu	Lys
Pig		-	-	-	-	-	-	-	-	-	-	Val	Gln	-	-	Ala	-	-	-	-	-	-	-
Chicken		-	-	Ile	-	-	-	-	-	-	-	Val	Gln	-	-	-	-	-	-	-	-	-	-
Dogfish		-	-	-	-	-	-	-	-	Val	-	Val	Gln	-	-	Ala	-	-	-	-	-	-	Asn
Drosophila	<<<	-	-	-	-	-	-	-	-	Leu	-	Val	Gln	Arg	-	Ala	-	-	-	-	-	-	Ala
Wheat	<<<	-	Asn	Pro	Asp	Ala	-	Ala	-	-	-	Lys	Thr	-	-	Ala	-	-	-	-	-	Asp	Ala
Yeast	<<<	-	Ser	Ala	Lys	-	-	Ala	Thr	Leu	-	Lys	Thr	Arg	-	Glu	Leu	-	-	-	-	-	-

Fig. 2.2

(i) Suggest what the data in **Fig. 2.2** indicate about the evolutionary relationships between humans and the other species.

all the species share a (recent) common ancestor ;
the smaller the number of differences the more closely related/more recently divergence occurred ;
example + data quoted;
e.g. pigs and chickens are phylogenetically closest to humans
e.g. yeast, is the most distantly related to humans (compared to any of the other sp.)
e.g. number of differences / description of bases at certain positions – see table below

Table of number of differences

	Human	Pig	Chicken	Dogfish	Drosophila	Wheat	Yeast
Human	0	3	3	5	6	10	11
Pig	3	0	2	2	3	9	11
Chicken	3	2	0	4	5	10	11
Dogfish	5	2	4	0	3	10	12
Drosophila	6	3	5	3	0	10	10
Wheat	10	9	10	10	10	0	11
Yeast	11	11	11	12	10	11	0

[3]

(ii) Explain why any such conclusions in (i) need to be treated with caution.

Ref to cyt being a large protein and only a small fraction is compared:
the compared sequences are only a small fraction of the whole genome + (figures) e.g. 22 amino acids shown in the table;
cytochrome is likely to be a larger, polypeptide/protein;

Ref to variation within each species:
these sequences come from one individual from each species, there will be variation within each species ; A small sample size/ use of amino acid sequences does not allow for detection of silent mutations in the genome due to degeneracy of genetic code;

Ref to changes not fully observed in amino acid sequence:
amino acid sequence only reflects the coding region of the DNA sequence thus changes in the non-coding regions will not be detected;

[2]

(e) Suggest how the differences in the amino acid sequences shown in **Fig. 2.2** may have come about.

(point mutation), change in a single base/ substitution ; R addition/ deletion/ frame shift
mis-pairing during DNA replication ;
mutagen/named mutagen ; A UV/X-rays / ionising radiation/AW;

[2]

(f) Suggest why the cytochrome c protein was chosen to compare amino acid sequences across the different species.

Cytochrome c protein is **ubiquitous** / will be present in all organisms because all organisms need to respire which serves as a good basis of comparison between organisms;

Essential / important gene which changes very slowly**,** useful for estimating time of divergence that occurred long time ago;

accumulates mutations at a constant rate and therefore can be used to calibrate a molecular clock for the estimation of time of divergence between species;

[1]
[Total: 20]

3 Dengue fever (DF) is a disease caused by infection with a virus transmitted by the *Aedes aegypti* mosquito. It is an acute viral infection characterized by fever, rash, headache and muscle and joint pain. Occasionally, dengue virus infections progress to dengue haemorrhagic fever (DHF) and dengue shock syndrome (DSS). There are 4 known serotypes of the disease-causing dengue virus. Individuals who become infected with one serotype obtain lifelong immunity against that serotype but not the other three.

Female *Aedes* mosquitoes are responsible for human-to-human transmission of the dengue virus. During blood feed, they acquire the proteins necessary for them to develop eggs. As a result of their short life cycle, they are able to multiply quickly, allowing dengue to spread.

(a) (i) State one reason why blood is a good source of protein.

Blood comprises red blood cells which contain haemoboglobin /

Blood plasma contains soluble proteins such as antibodies / protein hormones / clotting factors / enzymes /

Blood has white blood cells that contain / secrete proteins such as major histocompatibility complexes / cytokines / perforins / granzymes ;

AVP

[1]

(ii) Outline the life cycle of the *Aedes aegypti*.

Egg: Female *Aedes aegypti* mosquito lays eggs singly in moist places, such as inner walls of artificial containers, above the waterline;

Larva: When the water level rises (for e.g. rain), and the eggs get submerged in water, the eggs hatch and the larvae emerge after 1 – 2 days ;

Larvae feed on micro-organisms and particulate organic matter and breathe through a siphon at the water surface

The larvae go through larval stages (four instars and moult four times), after which they become pupa that do not feed and will develop into the mosquitoes' adult body form in two days ;

Adult: The newly form adult will emerge after breaking the pupal skin, resting on the water surface to dry and harden their exoskeleton before flying ;

[4]

Aedes aegypti originated in Africa but migrated to other continents via the slave trade in the 1500s and 1600s. The estimated range of the mosquito is primarily the tropics and sub-tropics but they have also been detected in countries with temperate climate such as parts of Europe and North America. As a result of the spread of *Aedes* vector across the globe, worldwide incidences of dengue have also been on the rise, posing huge public health concerns. **Fig. 3.1** shows the annual average number of both DF and DHF reported to the World Health Organisation (WHO) and the average annual number of countries reporting these cases from 1955 to 2007. The upward trend continues today.

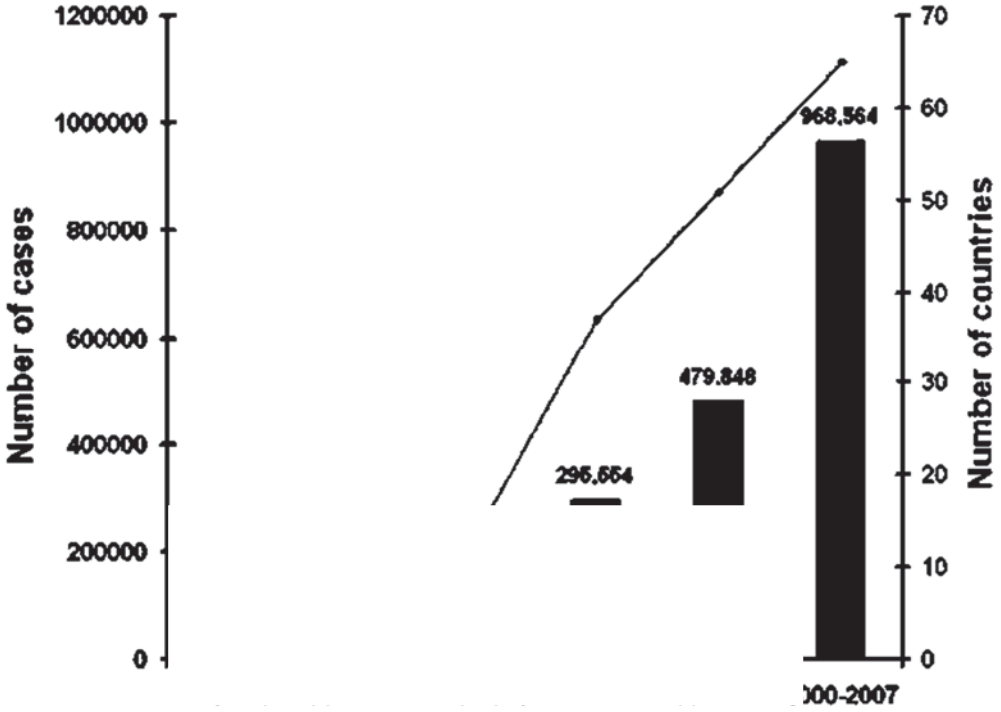


Fig. 3.1

While *increased* human population and global movement of people and cargo via air travel have undoubtedly assisted the spread of dengue, some scientists have attributed it to the effect of global warming.

Fig. 3.2 shows the global temperature departure (^{0}F) from the long-term average from 1880 to 2010. An additional trend line was plotted for the departure values between 1950 and 2010.

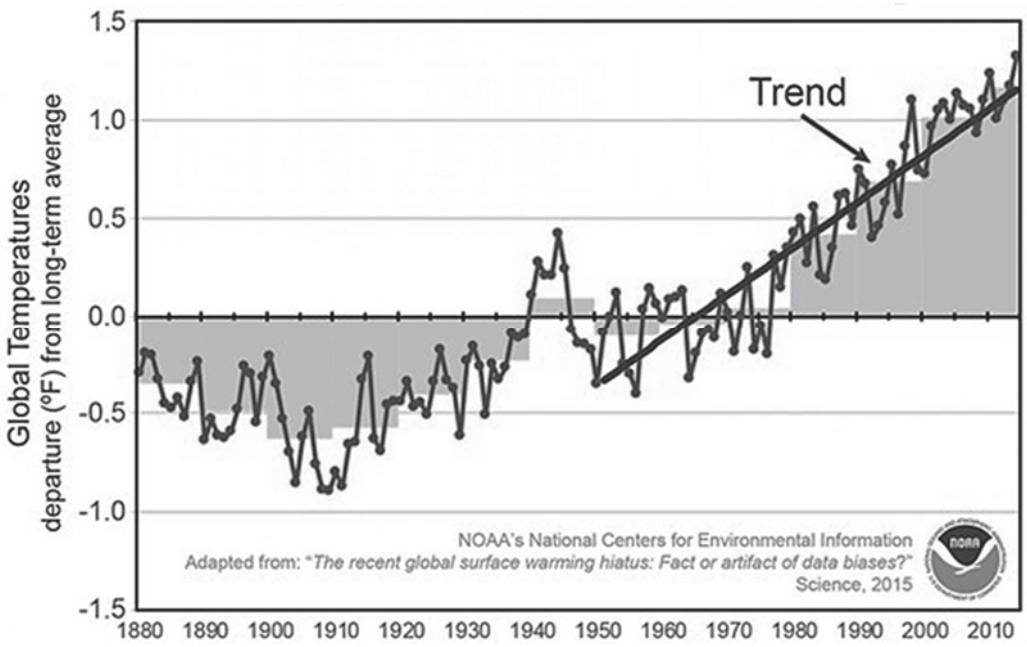


Fig. 3.2

(b) Using evidence from **Fig 3.1** and **Fig. 3.2** and your own knowledge of global warming,

(i) explain how the increase in global annual average number of DF / DHF could be caused by global warming.

Hypothesis supported:

As the global temperature departs more and more (positively), from 0^0F to 1.2^0F away from the long term average (denoted by 0^0F), the higher the annual average number of DF / DHF (increase from about 900 in 1955-1959 to about 970,000 in 2000-2007) ;

Explain: Global warming results in increase in global temperatures resulting in faster transmission of dengue virus from any one of the following :

- cold-blooded animals, hence body temperatures could increase with global warming → increase metabolic rate / shorten life cycle → faster growth and development /
- increase activity of female mosquitoes (increase biting rates) /
- increase egg-laying rates and more eggs laid per female /
- reduce the extrinsic incubation period of the virus within mosquito, so mosquito has a greater chance of infecting a human before it dies ;

[3]

(iii) suggest how global warming can lead to the spread of DF / DHF beyond the tropics into the temperate regions.

Global warming can lead to warmer winter temperatures in the temperate regions:

which may lead to the pole-ward range expansion of the mosquitoes, arriving in the now-warmer temperate regions earlier /

which may decrease mosquito mortality, causing them to survive the now-warmer winter season in the temperate regions, allowing them to continue multiplying throughout winter ;

(and leading to more rapid transmission of the dengue virus)

[1]

(c) *Wolbachia* is a natural bacterium present in up to 60% of insect species, but it is not usually found in the *Aedes aegypti* mosquito. Research has shown that when introduced into the *Aedes aegypti* mosquito, *Wolbachia* can stop the dengue virus from replicating inside the mosquito and hence prevent transmission to humans.

One possible way in which *Wolbachia* is used to suppress the *Aedes aegypti* mosquito population is through the release of male *Wolbachia-Aedes aegypti* mosquitoes. When these mosquitoes mate with the female wild-type *Aedes aegypti* that do not have *Wolbachia*, those females will lay eggs that do not hatch.

Country X released these male *Wolbachia-Aedes aegypti* mosquitoes in several housing estates as a form of vector control. Following three months of releases at the study site, the eggs were collected using ovitraps placed at several sites within the estate. The percentage of unhatched eggs were recorded for both the study and control sites.

(i) State a statistical test that could have been used to determine whether the difference in the mean percentage of unhatched eggs between the study and control sites is significant.

t-test ;

[1]

(ii) Suggest how a suitable control site was selected for the study.

same population density/ same housing type/ AVP;

[1]

(iii) A summary of the results is shown in **Table 3.1**.

Table 3.1

mean percentage unhatched eggs		**probablity**
study site	**control site**	
62.2	15.7	$p < 0.00001$

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

at 0.05 level of significance, the difference between the mean percentage of unhatched eggs in the study site and the control site is significant ;

The released male *Wolbachia-Aedes aegypti* mosquitoes have successfully mated with the wild-type female *Aedes* ; / control of mosquito using *Wolbachia* is effective;

[2]
[Total: 13]

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) Outline the role of ATP in living organisms using named examples. [13]

(b) Discuss how the survival of species depends on DNA molecules being stable yet not *absolutely* stable. [12]

[Total: 25]

5(a) Outline how variation can arise in any population of living organisms. [13]

(b) Discuss the suggestion that all living organisms on Earth depend on phosphate. [12]

[Total: 25]

QUESTION 4

(a) Outline the role of ATP in living organisms using named examples. [13]

Introduction:

1. Ref to ATP as the universal energy currency / carrier in cells of living organisms;
2. (Explain why) It is small and water soluble, hence can be transported within the cell easily / a lot of chemical energy is stored in the bonds of ATP / hydrolysis of the third phosphate group releases large amount of energy ;

In cellular/aerobic respiration:

3. Activation of glucose to glucose-6-phosphate via phosphorylation using ATP during the energy investment phase of glycolysis. This process is catalysed by hexokinase ;
4. ATP is required for the phosphorylation of fructose-6-phosphate to fructose-1,6-bisphosphate catalysed by phosphofructokinase ;
5. ATP also serves as an allosteric inhibitor to the phosphofructokinase enzyme ;

Uses in cellular activities:

6. Movement of secretory vesicles from the Golgi apparatus to the cell surface membrane along the cytoskeleton requires energy from the hydrolysis of ATP ;
7. Active transport of molecules against concentration gradient across the cell surface membrane via the action of a specific carrier proteins called "pump" which use ATP to change its conformation. E.g. is sodium-potassium pump ;
8. Bulk transport such as endocytosis and exocytosis involves the transport of large molecules like proteins and polysaccharides which require ATP. E.g. secretion of antibodies by plasma cells ;
9. ATP required for amino acid activation prior to translation for the covalent attachment of the amino acid to the 3' acceptor stem of the corresponding tRNA, catalysed by amino acyl tRNA synthetase;

In photosynthesis:

10. Energy from hydrolysis of ATP during Calvin cycle of the light-independent stage of photosynthesis in stroma of chloroplasts in plant cell is required to convert glycerate-3-phosphate (GP) to glyceraldehyde-3-phosphate (GALP) ;
11. Energy from hydrolysis of ATP is also needed to regenerate ribulose bisphosphate in Calvin cycle ;

Role of ATP as a nucleotide:

12. ATP is a ribonucleotide and is incorporated into mRNA acid during transcription ;

Role of ATP in cell signalling:

13. ATP is required as a substrate for the adenylyl cyclase enzyme, which upon activation by the activated GTP-bound G-protein, catalyses the conversion of ATP to cAMP, which serves as a second messenger in the signal transduction pathway ;
14. ATP is also the substrate for the kinases in the phosphorylation cascade, which catalyses the addition of phosphate groups from the ATP molecules to the subsequent kinases in the cascade ;

(b) Discuss how the survival of species depends on DNA molecules being stable yet not *absolutely* stable. [12]

DNA as a stable molecule:

1. In the DNA double helix, the nitrogenous bases are held together by extensive / numerous hydrogen bonds ;
2. Complementary base-pairing via two hydrogen bonds between adenine and thymine, and three hydrogen bonds between cytosine and guanine ;
3. Extensive hydrophobic interactions between the stacked bases, stabilise the structure of the double helix ;
4. The adjacent nucleotides within each polynucleotide strand are held together by strong covalent phosphodiester bonds, which are not easily broken. In this way, the integrity of the DNA base sequence is maintained ;
5. Proof-reading ability of DNA polymerase ensures DNA molecule is replicated correctly and accurately / nucleotide sequences are intact ;

(Note: Idea of "numerous/extensive" bonds must be mention at least once in this part for students to attain the full 5 marks for this section)

Why DNA may not be absolutely stable:

6. Affected by mutagens that damage DNA or introduce random mutations ;
7. For e.g. physical factors such as ionising radiation like gamma rays / X-rays which cause formation of chemically active ions in the cells which are capable of damaging and breaking DNA OR Absorption of UV light causes DNA to increase in energy level, causing damage to DNA double helix by creating kinks ;
8. For e.g. chemical factors (carcinogens) such as ethidium bromide that cause chemical changes in bases resulting in incorrect base pairing, results in insertion or deletion of base pair ;
9. Allow small changes in nucleotide sequences through point mutations, generating new alleles and hence genetic variation in a population ;

Survival of species:

10. With genetic variation, there is heritable variation for natural selection to act upon in a population ;
11. Due to different proteins/gene products generated that could confer selective advantage for some individuals ;
12. Ref to selection pressure, only individuals best able to adapt will survive and produce fertile and viable offspring ;
13. Passing down beneficial alleles from parents to offspring ;
14. If DNA totally stable, no new alleles / mutations / traits, which will reduce survival ability of the species ;
15. Ref to how DNA not being totally stable allows heterozygote advantage, e.g. heterozygotes / carriers of sickle-cell anaemia individuals are malaria-resistant (greater fitness) than homozygous dominant or homozygous recessive individuals ;

Conclusion:

16. Ref to continuation of a species and its continued evolution relies on a balance between accurate transmission of nucleotide sequences and the need for random change to provide the variation needed to allow continued evolution, depending on selection pressure ;

QUESTION 5

(a) Outline how variation can arise in any population of living organisms. [13]

In sexually reproducing population

1 Meiosis and fertilisation generates the genetic variation within a sexually reproducing population;
2 During prophase I, ***crossing over*** occurs between the non-sister chromatids of homologous chromosomes;
3 leading to new allelic combinations on a chromosome;
4 During metaphase I, ***independent assortment**** of ***homologous chromosomes**** occurs where the orientation of bivalents is random, as chromosomes line up along the metaphase plate;
5 leading to different chromosomal combinations in different gametes;
6 2^n different combinations of (chromosomes in) gametes, where n represents the haploid number of chromosomes in the species, can be obtained as a result of meiosis;
7 Random fusion / fertilisation of these gametes carrying different combinations of chromosomes adds to genetic variation of the zygote formed;

*In asexual reproducing p*opulation (Bacteria)

Transformation

8 Bacterial cells take up foreign DNA from the surrounding medium via a cell surface receptor
9 Incorporating / integration of foreign DNA into its own DNA (via homologous recombination)

Transduction - Award marks either for generalized or specialised transduction only

10 A phage infects and injects its DNA into a bacterium and replicate in the cell.
11 Due to mistakes in the phage's reproductive cycle, a small piece of bacteria DNA was incorporated into the phage capsid
12 The resulting transducing phages infect other bacteria and newly infected cell acquires the original bacterial DNA / original bacterial DNA integrates into the DNA of the recipient

Conjugation

13 Attachment of F^+ and F^- bacterium via sex pilus made by F+ cell. Sex pilus retracts, the two bacteria cells come into physical contact via conjugation tube/mating bridge
14 Single strand of F plasmid breaks at origin of transfer and move into recipient bacterium through conjugation tube

In both populations

15 Mutations occurs to generate new alleles reference to gene mutation or chromosomal mutation

(b) Discuss the suggestion that all living organisms on Earth depend on phosphate. [12]

Cell membranes (max 4)

1 All living organisms have cell membranes require phosphate for phospholipids;
2 Phospholipids help to regulate what enter or leaves the cell or the organelles (idea of partial permeability);
3 Phospholipids contribute to the fluidity of cell membrane;
4 Allowing processes such as endocytosis / exocytosis to occur;
5 ref to phosphate being negatively charged allowing interaction with aqueous medium/ allowing bilayer to form;
6 allowing embedding of proteins in membrane;

Nucleic acids (max 3)

7 The genetic code depends on nucleic acids;
8 The backbone of nucleic acids is a sugar-phosphate chain / nucleic acid are made up of nucleotides comprise phosphate group, pentose sugar and nitrogenous base
9 Therefore without nucleic acids no storage of genetic information;

ATP (max 3)

10 Most energy are stored in the bonds of ATP; idea of ATP is energy currency within the cell;
11 The hydrolysis of the third phosphate group releases large amount of energy/ ATP more energy reach than ADP;
12 ref to use of ATP in a specific eg. (transcription, amino acid activation, active transport, endo- exocytosis, AVP)

Photosynthesis (max 3)

13 NADP is a coenzyme which can be reduced as it can carry high energy electrons and protons;
14 Oxidised NADP is the final proton and electron acceptor during non-cyclic photophosphorylation in light-dependent reaction;
15 Reduced NADP provides the reducing power to convert glycerate-3-phosphate to glyceraldehyde phosphate in the Calvin cycle;

Cell signaling (max 3)

16 When RTK dimerises, the tyrosine kinase function is activated resulting in autophosphorylation of tyrosine residues in the tails of the RTK, activating the receptor/ Activation of G-protein by GTP;
17 Each activated protein kinase will initiate a sequential phosphorylation and activation of other kinases, resulting in a phosphorylation cascade.
18 At each catalytic step in the cascade, the number of activated products is much greater than those in the preceding step resulting in signal amplification.
19 reference to cAMP as second messenger in signal transduction pathway;

AVP;

20 GTP used in translation;
21 GTP used in substrate level phosphorylation in Krebs cycle

NANYANG JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME **ANSWERS**

CLASS

BIOLOGY

9744/04

Paper 4 Practical

25 August 2017

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	
3	
Total	

Answer **all** the questions.

1 You are required to determine the concentration (in $mgcm^{-3}$) of ascorbic acid (Vitamin C) and glucose in a sample of orange juice.

Proceed as follows:

I. The ascorbic acid test

You have been provided with standard solutions containing **0.5, 1.0, 2.0** and **4.0** $mgcm^{-3}$ of ascorbic acid respectively. These solutions reduce the dye dichlorophenol indophenol (DCPIP) from blue to colourless:

DCPIP (blue) $\xrightarrow{\text{ascorbic acid}}$ reduced DCPIP (colourless)

Using a syringe, place 2 cm^3 of DCPIP solution in a test tube. Place the test tube in a rack. Fill a 2 cm^3 syringe with **4.0 $mgcm^{-3}$** ascorbic acid solution. Add this solution, drop by drop, to the DCPIP solution, stirring gently with a glass rod after each drop. Determine the number of drops needed to decolourise the DCPIP solution.

(a) (i) Note this number in the table 1 below.

Table 1

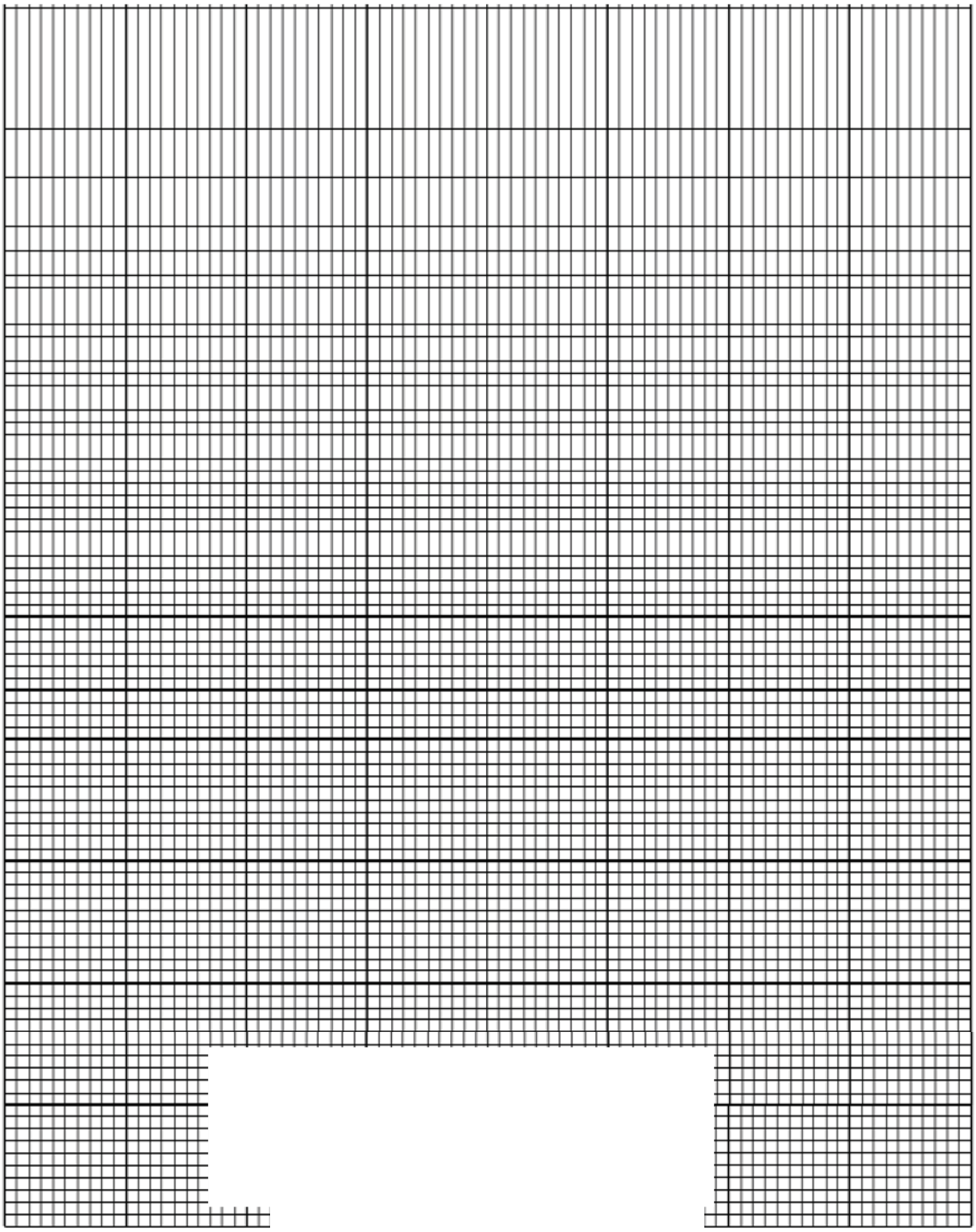
Concentration of ascorbic acid / $mgcm^{-3}$	number of drops needed to decolourise DCPIP
4.0	10
2.0	18
1.0	35
0.5	67
Orange juice	30 – 40 drops

The higher the concentration of ascorbic acid, lesser the number of drops needed to decolourise DCPIP;
Orange juice number of drops = **30- 40 drops**;

Repeat this procedure, using fresh samples of DCPIP each time, with the other **three** solutions of ascorbic acid and, finally, with the orange juice with which you have been provided.

(ii) Add these results to the **Table 1**. [2]

(iii) Plot a graph using the data in **Table 1**. [4]



1 Correct orientation of the axes and correct labels with units;
x-axis: concentration of ascorbic acid solutions / $mgcm^{-3}$
y-axis: number of drops of ascorbic acid added
2 Appropriate scale and no awkward scale;
3 all points accurately plotted;
4 best fit **curve**;

(iv) Use the data you have obtained to determine the ascorbic acid concentration in the sample of orange juice. Explain how you arrive at your answer.

Using the number of drops of orange juice needed to decolourise DCPIP, find the corresponding ascorbic acid concentration from the graph;

Ascorbic acid concentration in orange juice = _____ $mgcm^{-3}$ (read off the graph accurately) ;

[2]

II. The ascorbic acid test

You have been provided with a 4% (by mass) solution of glucose, distilled water and Benedict's solution. Using only the apparatus provided, devise and carry out a procedure by which you can make the Benedict's test quantitative in order to determine the glucose concentration (in $mgcm^{-3}$) of orange juice. You should work with five different glucose solutions covering the range from 0.1% to 4% by serial dilution.

Note: In your tests you are advised to use 5 cm^3 of Benedict's solution to 0.5 cm^3 sample of all solutions.

(b) (i) Describe your method and show the results you obtained in a table.

Carry out serial dilution of the stock solution / 4% of glucose using the table below;

Carry out Benedict's Test for known glucose concentration and orange juice and place into boiling water bath for 2 minutes ;

Compare the colour of the Benedict's test of orange juice with the colour standards;

Concentration of glucose /%	Volume of distilled water/ cm^3	Volume of previous glucose / cm^3
4	0.0	10.0
2	5.0	5.0
1	5.0	5.0
0.5	5.0	5.0
0.1	8.0	2.0

Concentration of glucose /%	Observations
4.0	
2.0	
1.0	
0.5	
0.1	

Table heading;
Description of colour and suspension;

[5]

(ii) Estimate the glucose concentration of the orange juice in $mgcm^{-3}$.

greater than 4%;

greater than $40mgcm^{-3}$ (4/100 * 1000);

[2]

(iii) Describe two other modifications to your method that would increase confidence in the conclusions and explain how these modifications would achieve this.

1

Dilution of the orange juice and ref to [glucose] multiply by the dilution factor /
Increase range of glucose concentration and match according

As glucose concentration of orange falls out of the range of the colour standards

2

Use colourimeter to determine quantitatively the amount of glucose present.

Difficulty in judging the colour differences between the Benedict's Test results of test solutions and the standard solutions / cannot find match with colour standards

@ repeats experiment twice + increase reliability of results;;

[4]

To a clean test-tube, add 2 cm^3 of DCPIP solution. Using a 2 cm^3 syringe as before, add the same number of drops of 4% glucose solution as you did of the 0.5 $mgcm^{-3}$ ascorbic acid (which you have recorded in **Table 1**).

(c) Note your observations.

DCPIP remains blue

[1]

Carry out Benedict's test using the 4.0 $mgcm^{-3}$ ascorbic acid solution.

(d) Note your results.

Ascorbic acid produce a positive Benedict's Test (blue with a tinge of red);

[1]

(e) State the significance of the procedures which you carried out in **(c)** and **(d)** for the interpretation of your results in **(a)** and **(b)**.

To check if glucose will affect DCPIP decolourisation and ascorbic acid will affect Benedict's Test

Glucose, will not decolourise DCPIP solution

Ascorbic acid, like glucose will produce a positive Benedict's Test

Able to determine the concentration of ascorbic acid and but not glucose concentration in orange juice;

[3]

[Total: 24]

2 You are required to investigate the effects of sucrose and potassium nitrate (KNO_3) solutions on the cells of the plant material supplied. Peel off several pieces of epidermis from the pigmented areas of the plant tissue, taking care to remove as little as possible of the underlying tissue. Cut the pieces of epidermis so that you have four squares of tissue each approximately 0.5 x 0.5cm. Place these in a dish of distilled water.

Take one piece of epidermis and mount it in distilled water on a microscope slide. Cover with a cover slip. Using your microscope, find an area of the tissue where pigmented cells can be seen clearly, preferably as a single layer of cells.

(a) Describe the distribution of the coloured contents within the cells.

pigment is uniformly / evenly distributed in all cells / coloured content filled the entire cell;

[1]

Mount another piece of epidermis in 1 mol dm^{-3} sucrose solution. Blot off excess water with filter paper before you add the solution.

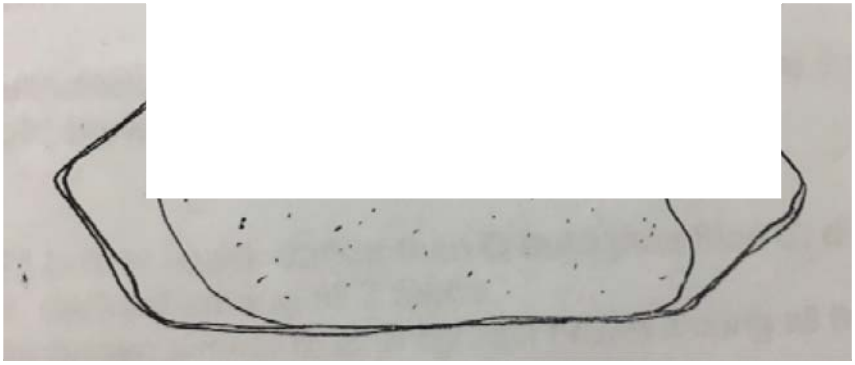
(b) (i) After about one minute, make a large labelled drawing to show the detailed structure of one epidermal cell which is typical of the most deeply coloured cells which you can see.
Max four from:

1 Use clear continuous lines (quality of line) with no shading, cellulose cell wall shown as double lines;

2 only one cell drawn + *shows expected degree of* plasmolysis (with detached cell membrane from cell wall with some intact attachment points) ;

3 Correct relative proportion of thickness of cell wall to cell / cell shape typical of onion cell (longish, rectangular);

4 At least 3 correct labels: cell wall, cell surface membrane, cytoplasm, external solution / sucrose solution , vacuole



[4]

(ii) Describe and explain for the appearance of the cells when placed in 1 mol dm^{-3} sucrose solution.

(description) cell surface membrane pulled away from cell wall ;

(description) purple pigment looks denser/darker within the cell;

water moved from a region of less negative water potential (inside the cell) into a region of more negative water potential (the surrounding sucrose solution) through a partially permeable membrane via osmosis; (ref to direction of movement and process)

pigments retained within vacuole because of high molar mass;

[3]

Mount another piece of epidermis in 1 mol dm^{-3} potassium nitrate solution. Immediately observe the detailed structure of a typical pigmented cell.

(iii) Compare the appearance of this cell with that drawn in **(b)(i)**.

more extensive plasmolysis;

pigment/ purple colour looks more intense;

cell content looked broken/ fragmented/ “dried up” in some cells

[2]

(iv) Suggest a reason for the differences in the appearances of the two cells in the two solutions.

KNO_3 dissociates in water to give twice the solute concentration/ K^+ and NO_3^-

more negative water potential in the external solution compared to inside cell;

gradient is steeper, more water moves out of cell via osmosis;

[2]

(c) Several chemicals are known to affect membrane permeability.
Suggest how ethanol may have an effect on onion epidermis.

Ethanol: It dissolves the phospholipids;

Or As the polar –OH group in ethanol can form interactions with polar phosphate head of the phospholipid;

Purple pigments will leak out of the cell as tonoplast & cell surface membrane is disrupted

[2]

(d) **Fig. 2** is a stained transverse section through part of the stem of a different plant species. You are not expected to be familiar with this specimen.

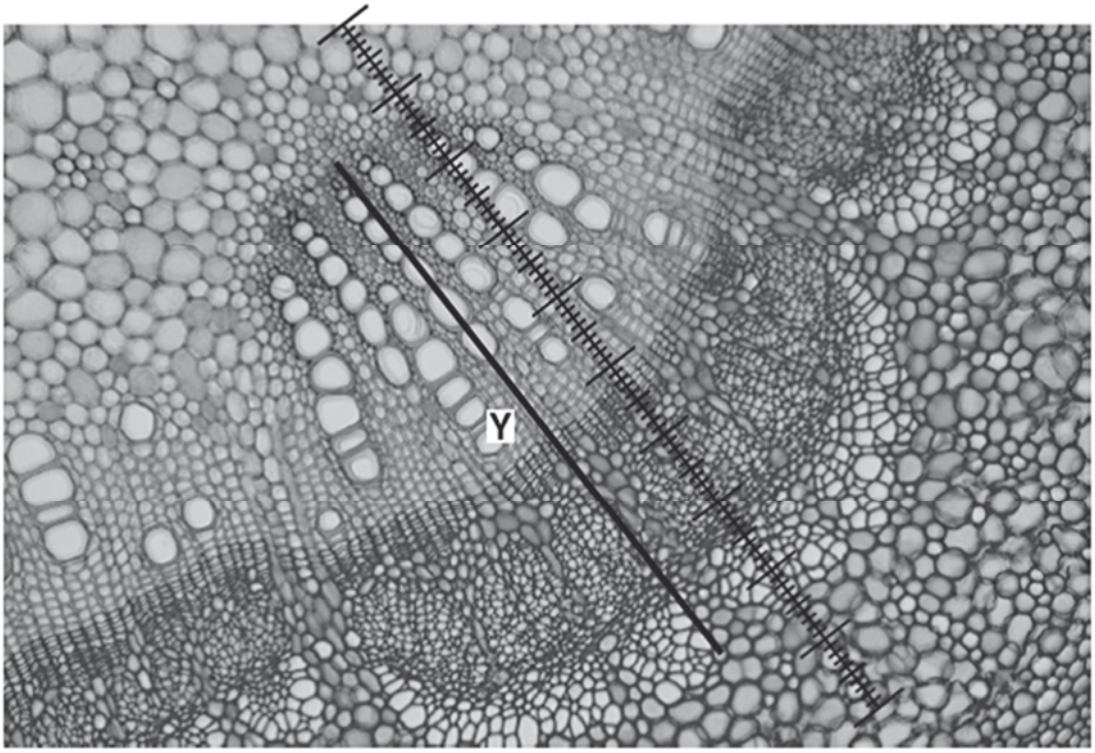


Fig. 2

A student calibrated the eyepiece graticule in a light microscope using a stage micrometer scale so that the actual length of the vascular bundle could be found.
The calibration was: one eyepiece graticule division equal to 11 µm.

Fig. 2 shows a photomicrograph taken using the same microscope with the same lenses as the student. Use the calibration of the eyepiece graticule division and **Fig. 2** to calculate the actual length of the vascular bundle, shown by line **Y**.

You may lose marks if you do not show all the steps in your working and do not use appropriate units.

72 (±1) division x 11 µm = 792 µm
records correct number of eyepiece graticule units ;
shows multiplication by 11 ;
correct answer + units ;

[3]

[Total:17]

3 All green plants photosynthesise in the light, taking in carbon dioxide and releasing oxygen. They also respire continuously, taking in oxygen and releasing carbon dioxide. The light intensity at which photosynthesis and respiration occur at the same rate, so that there is no net gas exchange, is called the compensation point.

Compensation points can be investigated using hydrogencarbonate indicator solution. This is harmless to living organisms but changes colour over a range of concentrations of carbon dioxide due to changes in pH, as shown in Table 3.1.

Table 3.1

increasing CO_2 in indicator ←			atmospheric CO_2 level			decreasing CO_2 in indicator →		
yellow		orange		red		magenta		purple
pH 7.6	pH 7.8	pH 8.0	pH 8.2	pH 8.4	pH 8.6	pH 8.8	pH 9.0	pH 9.2

Hydrogen carbonate indicator is red in equilibrium with atmospheric air. It changes from red to magenta to deep purple as carbon dioxide concentration decreases. It changes from red to orange to yellow as carbon dioxide concentration increases

Monitoring the colour of hydrogencarbonate indicator solution in sealed vessels containing plant material can show whether carbon dioxide is being taken in or given out.

One factor that can affect the compensation point is whether a leaf is adapted for low light intensities (shade leaf) or high light intensities (sun leaf). Shade leaves would be expected to reach their compensation points at a lower light intensity than sun leaves.

Light intensity = $1/d^2$, where d represents the distance from the light source

Some plants produce both shade and sun leaves depending on where the leaves develop. For example, an aquatic plant can produce sun leaves at the top where they are in direct sunlight and produce shade leaves lower down where light intensity is reduced.

Using this information and your own knowledge, design an experiment to find the light intensity at which shade leaves and sun leaves from an aquatic plant reach their light compensation points.

Comparison of the results would then allow testing of the hypothesis that shade leaves reach their compensation points at a lower light intensity than sun leaves.

You must use:

- hydrogencarbonate indicator solution
- colourimeter and cuvette
- sun and shade leaves from an aquatic plant.

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- bungs
- bench lamp with 60W bulb

Your plan should:

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

[Total:14]

Suggested answer:

Theory (1m max)

- Respiration: Reference to decarboxylation during Krebs cycle, release carbon dioxide
- Photosynthesis : Ref to carbon fixation during Calvin cycle catalyzed by Rubisco

Independent variable:

- light intensity and uses at least five different light intensities uniformly spaced or derived, e.g. regularly increasing distance from light source.

Dependent variable

- Absorbance / Light transmission measuring the colour change in hydrogencarbonate indicator solution.

Variables kept constant:

- size / area of leaves used (e.g. mass / length / same species),
- Temperature,
- fixed duration of light exposure
- Volume of indicator,

Procedure:

- Annotated diagram

- Control:
    1. Repeat the experiment replace leaves with glass beads (inert object)

- Repeats/replicates:
    1. Repeat the experiment at least two more times with fresh sun and shade leaves

- Key steps:

1. Select and carefully remove 1 sun leaf and 1 shade leaf of similar leaf area from the same aquatic plant.
2. Label two boiling tubes, “sun” and “shade”.
3. Using a syringe, measure 10 cm^3 of hydrogencarbonate indicator into each of the boiling tubes.
4. Ensure that the starting colour of the indicator solution is red.
5. Fit each tube with a rubber bung and wrap both tubes with aluminium foil.
6. Set-up a 28.0^{0}C water bath using a large beaker as shown in the diagram. Place the boiling tubes in the water bath and let it equilibrate for 2 minutes.
7. Using a metre ruler, measure a distance of 25 cm from the beaker and place the bench lamp with 60W bulb at the spot.
8. Place the sun and shade leaves into the respective boiling tubes and make sure that them are fully submerged. Ensure that both test tubes are tightly sealed using petroleum jelly around the rubber bungs.
9. Remove the foil from the boiling tubes. Turn on the bench lamp and start the stopwatch. Record the colour change of the hydrogencarbonate indicator at the end of 5 minutes.
10. Set up a control test tube using steps 1-9, replacing the leaf with a glass bead of similar mass.
11. Calibrate the colorimeter to green light using the solution from the control test tube.
12. Transfer 1ml of the hydrogencarbonate indicator solution into a cuvette after 5 min and measure the colour intensity of the solution using a particular wavelength (green light).
13. Repeat steps 4 – 10 with the bench lamp placed at varying distances in decreasing order from 20, 15, 10 and 5 cm away from the beaker.
14. Repeat steps 1 – 11 twice using a fresh set of sun and shade leaves to obtain two more readings to calculate mean.
15. Record the data in a suitable format. Calculate the mean light intensity for the sun and shade leaves to reach light compensation point.

Data recording and processing:

distance of the lamp from the beaker / cm	Light intensity, $1/d^2$ /cm^{-2}	Absorbance / %			
		1	2	3	Mean
25					
20					
15					
10					
5					

Graph with axes drawn correctly;

Risks and precautions: (reference to hazard and precaution)

- Be careful when handling the bench lamp and avoid touching the hot light bulb with your bare hands.
- Be careful when plugging in the electric cable that connects to the bench lamp to avoid electric shock.

Confidential Instructions:

Candidates are advised to spend no more than:

- **60 minutes** on **Question 1**.
- **50 minutes** on **Question 2**.
- **35 minutes** on **Question 3**.

Apparatus List

Candidates will require:

Question 1

1 DCPIP
2 Ascorbic acid (AA) labelled
0.5 $mgcm^{-3}$,
1.0 $mgcm^{-3}$,
2.0 $mgcm^{-3}$ **and**
4.0 $mgcm^{-3}$
3 4% glucose
4 Distilled water
5 Benedict's solution
6 Orange juice
7 **12** Test tubes
8 **1** test tube rack
9 **1** test tube holder
10 **3** 2-ml syringes
11 **2** 5-ml syringes
12 **1** Glass rod
13 **1** dropper
14 **4** 50-ml beakers
15 **1** 250ml beaker
16 **1** 500ml beaker
17 **1** stopwatch
18 **1** wire gauze
19 **1** Bunsen burner
20 **1** tripod stand
21 **1** lighter
22 **1** wash bottle labelled as **distill water**
23 **1** pair of goggles
24 **1** permanent marker

Question 2

1 Red onions
2 1M Sucrose
3 1M Potassium nitrate (**oxidising**, **toxic**)
4 **1** Petri Dish
5 **2** microscopic glass slide
6 **2** cover slips
7 **4** droppers
8 **2** filter papers
9 **1** pair of scissors
10 **1** forceps
11 **1** mounted needle