VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2018

NAME : _____

CT CLASS : _____

H1 BIOLOGY **8876/02**

Paper 2 **2 hours**

READ THESE INSTRUCTIONS FIRST
Write your Name and CT class on all the work you hand in.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question.
Write your answers on separate answer paper provided.

At the end of the examinations,
1. hand in section A and the one question you attempted from section B separately;
2. fasten all your work securely;
3. enter the number of the section B question you have answered in the grid opposite.

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
Section B	
Total	

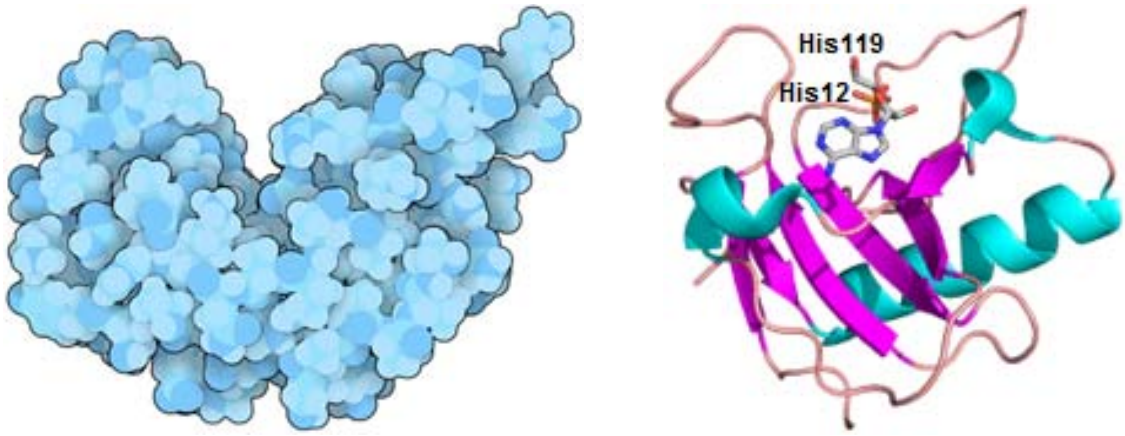
This document consists of **13** printed pages and 1 blank page

[Turn over]

Section A [45 marks]

Answer all questions.

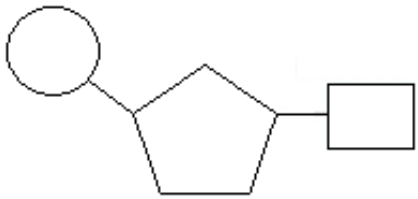
1 In eukaryotic cells, the degradation of mRNA is an essential part of the regulation of gene expression. It can be controlled in response to developmental, environmental, and metabolic signals. mRNA hydrolysis is catalysed by numerous types of nucleases, such as the endonuclease Ribonuclease A (RNAse A), shown in Fig. 1.1.



(A) Space-filling model (B) Ribbon diagram

Fig. 1.1

(a) Using a labelled and annotated diagram, illustrate the hydrolysis of the bond catalysed by RNAase.
(A monomer has been drawn for you.)



[2]

Fig. 1.1B shows two important catalytic residues within the active site of RNAse A, which are His12 and His119.

(b) Explain how these two histidines, which are in position 12 and 119 of the 124 amino acid sequence, are brought together in the active site of the enzyme.

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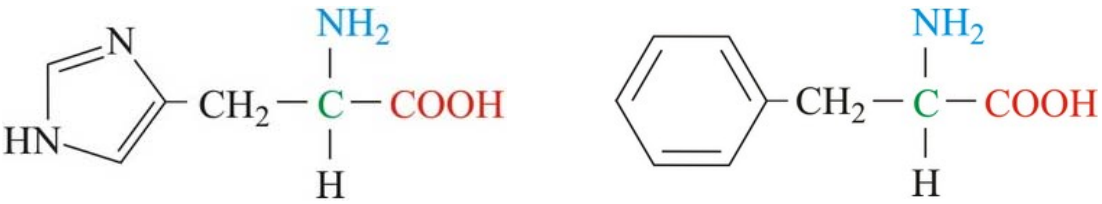
…… [3]

Fig. 1.2 shows the structure of histidine and phenylalanine.



(A) Histidine (B) Phenylalanine

Fig. 1.2

(c) Predict and explain how the catalytic activity of RNAse would be affected if both histidines were replaced by phenylalanines.

……

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…… [2]

Ribonuclease A is also the enzyme that digests RNA in our food. It is released by the pancreas of most mammals and some reptiles. Because it is small, stable, and easily purified, ribonuclease has been an important enzyme in biochemical research. In one procedure for purifying RNAse A from bovine pancreas, extracts are treated with mild sulfuric acid and then heated almost to boiling, leaving RNAse A as the only protein remaining intact.

(d) Suggest why RNAse A has such a stable structure and why it needs to be very stable. [2]

……..

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……. [2]

[Total: 9]

2 Table 2.1 shows some mRNA codons and the amino acids for which they code.

amino acid	abbreviation	mRNA					
glutamic acid	glu	GAA	GAG	–	–	–	–
phenylalanine	phe	UUU	UUC	–	–	–	–
lysine	lys	AAA	AAG	–	–	–	–
proline	pro	CCA	CCC	CCG	CCU	–	–
threonine	thr	ACA	ACC	ACG	ACU	–	–
valine	val	GUA	GUC	GUG	GUU	–	–
cysteine	cys	UGC	UGU	–	–	–	–
arginine	arg	CGC	CGA	CGU	CGG	AGA	AGG

Table 2.1

Fig. 2.2 shows the sequence of three amino acids in the human lysozyme polypeptide.

amino acids	arg	cys	glu
tRNA	.....	.....	.....
Template strand DNA	.....	.....	.....

Fig. 2.2

(a) Use the information in Table 2.1 to fill in any one possible tRNA anticodon and corresponding DNA sequence for each amino acid shown in Fig. 3.2. Write your answers in Fig. 2.2. [1]

(b) Explain what an “anticodon” is and its significance in the synthesis of proteins.

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……. [3]

A student drew how DNA is replicated as shown in Fig. 2.3.

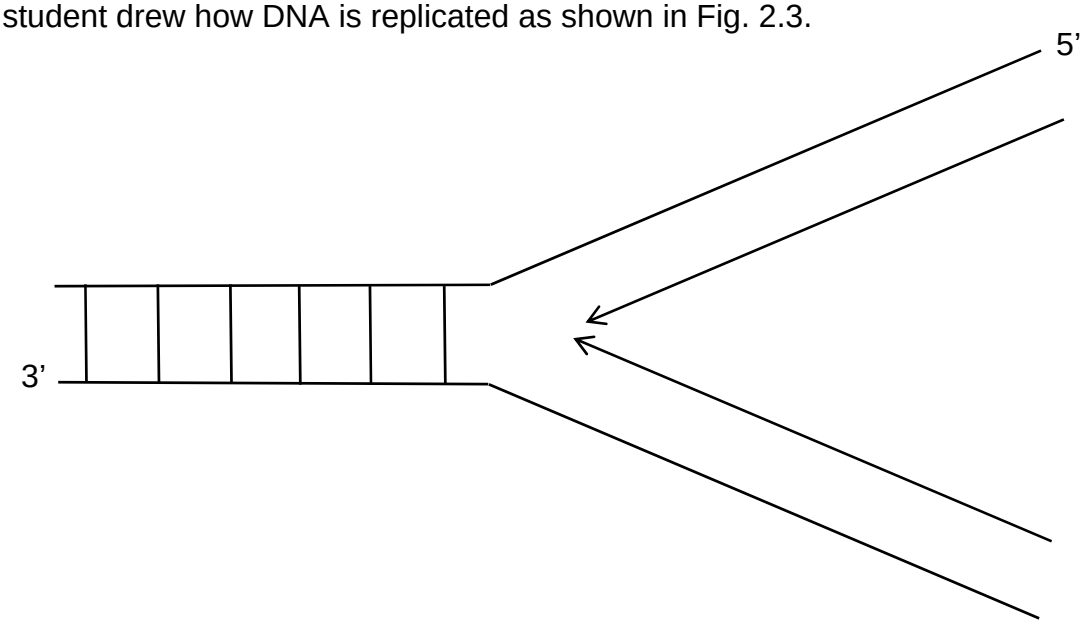

Fig. 2.3

(c) Evaluate the accuracy of the student’s drawing.

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……. [3]

[Total: 7]

3 (a) Structure **Q** in Fig. 3.1 is a cell structure which is involved in nuclear division.

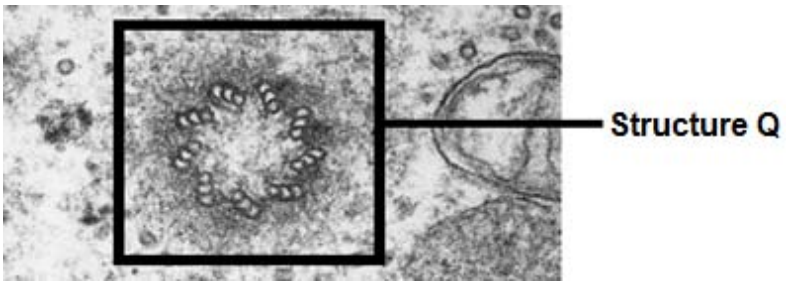

Fig. 3.1

(i) Identify structure Q and outline its role in nuclear division.

……

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…… [2]

(ii) Compare the structure of Q and a ribosome.

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…… [3]

(b) Chickpeas contain a lipase inhibitor that prevents the activity of the enzyme in the digestion of fats. There are two forms of lipase inhibitors – inhibitor **W** and inhibitor **X**.

Homozygous plants are known to produce one type of lipase inhibitor, depending on the allele which they are homozygous for. A heterozygote plant with both types of alleles, on the other hand, will have two types of lipase inhibitor, inhibitor **W** and inhibitor **X**. A third recessive allele does not code for any lipase inhibitor.

(i) State and explain the mode of inheritance for the lipase inhibitor in the chickpeas.

……

……

…… [2]

A second character, seed texture, is controlled by another gene located on a different chromosome and is controlled by two alleles. Smooth seed-coat, **T**, is dominant over wrinkled seed-coat, **t**.

Two chickpea plants were crossed. One of them contains only inhibitor **X** and has smooth seed-coats. Their seeds were collected and counted, as summarised in Table 3.2.

Inhibitor(s) present in seed	Number of seeds	Seeds with smooth seed-coat / %
W and **X**	12	50
W	14	50
X	22	50

Table 3.2

(ii) Using suitable symbols, draw a genetic diagram to explain the results of this cross, as shown in Table 3.1.

[5]

[Total: 12]

4 In an experiment to investigate the effect of various environmental factors on seed germination, germinating soybeans were exposed to different temperatures and light intensities. Fig. 4.1 shows the experimental set-up.

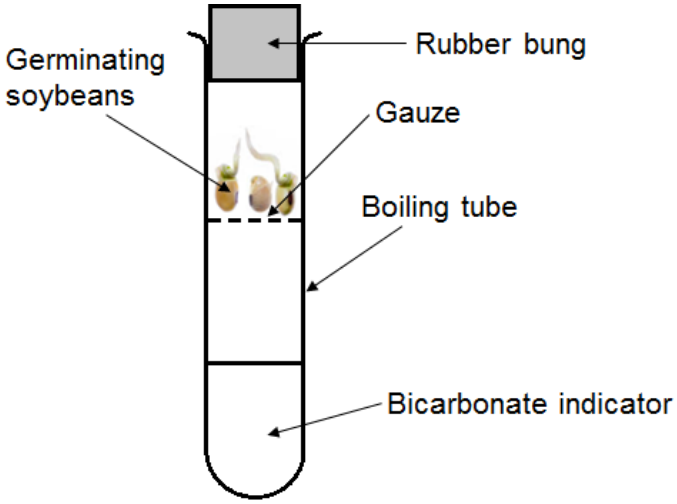

Fig. 4.1

Bicarbonate indicator is a pH indicator. It changes colours as the pH changes. At the start of the experiment, the bicarbonate indicator is at pH 7.

The set-up is left under different temperatures and light intensities for one hour, and the change in pH is recorded. Table 3.1 shows the results.

Temperature / °C	Light intensity	pH of bicarbonate indicator after 1 hour
10	High	6.5
10	Low	6.5
20	High	6.0
20	Low	6.0
30	High	5.0
30	Low	5.0
40	High	4.5
40	Low	4.5

Table 4.1

(a) (i) Explain the reason for the drop in pH of the bicarbonate indicator.

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…… [2]

(ii) With reference to the information provided, explain the effect of light intensity on the germination of soybeans.

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Studies on cancer cells found that fast-growing cancer cells require much more energy than normal cells, which explains the much higher rate of glucose uptake into cancer cells. However, it is also found that, unlike normal cells, the higher glucose uptake reduces oxygen uptake into cancer cells. This respiratory inhibition is known the Crabtree effect.

(b) (i) Besides the need for more energy for cell division, explain why cancer cells utilise glucose at a much higher rate than normal cells to produce energy.

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……. [2]

(ii) Cancer cells undergo anaerobic respiration in the same way mammalian muscle cells do. Compare the difference between anaerobic respiration in cancer cells and yeast cells.

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……. [1]

(c) Explain why ATP is regarded as the universal energy currency.

……..

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……. [2]

[Total: 9]

5 It is predicted that by year 2100, global warming may be a lot more severe than expected should greenhouse emissions continue to proceed at the current rate. Global temperatures can potentially increase by as much as 5^{o}C.

Insects are known to be sensitive to temperature changes and they face risks associated with global warming. A study conducted on 50 fruit flies suggested that limiting global warming to 1.5^{o}C would save the vast majority of the world's insect species from climate change.

(a) Outline how global warming can impact insects negatively.

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Reducing the risk to insects is particularly important, the research team say, as the effect of climate change on them can potentially implicate human beings.

(b) Suggest how the impact of climate change on insects can potentially implicate humans.

……..

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……. [2]

(c) Some scientists, however, believe that insects could evolve to become more heat-tolerant in the future. Explain how natural selection may lead to the evolution of more heat-tolerant insect species.

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……. [4]

[Total: 8]

Section C [15 marks]

Answer **one** question in this section. Each question has a part (a) and part (b).

Write your answers on the writing paper provided, with each part on a fresh sheet of paper.

Your answers should be in continuous prose, where appropriate.

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

6 (a) The Taq polymerase is a thermostable DNA polymerase named after the thermophilic bacterium ***Thermus aquaticus*** from which it was originally isolated from.

With reference to different levels of protein structure, explain how it is possible for both human DNA polymerase and the Taq polymerase to act on the same substrates, but for the Taq polymerase to have a higher optimum temperature [6]

(b) Explain, using examples, the significance of the fluid mosaic model to the functions of membranes at the cell surface or within cells. [9]

[Total: 15]

7 (a) Explain how genes are inherited from one generation to the next via the germ cells or gametes. [6]

(b) Bone marrow contains many stem cells. Some of these stem cells are responsible for the replacement of red blood cells. During the production of red blood cells, a series of changes occur to the cell structure.

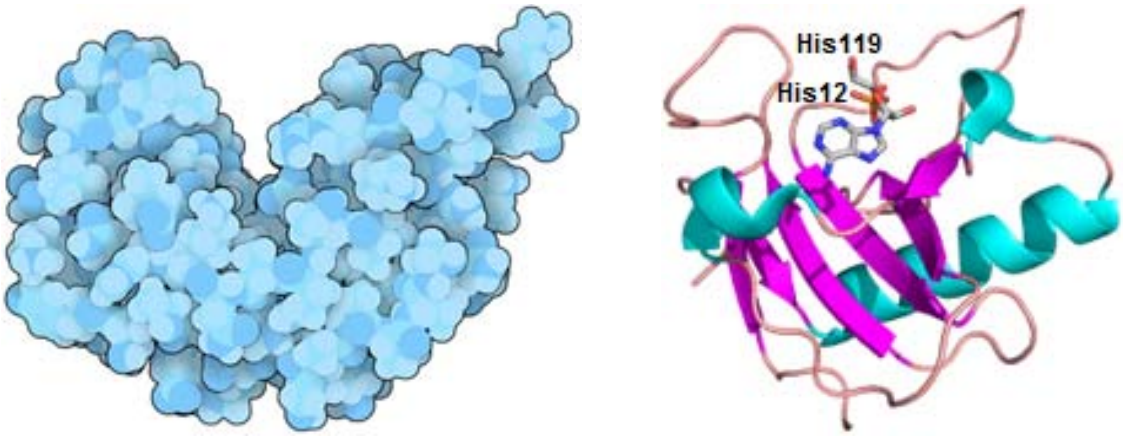
Describe the features of the stem cells responsible for production of red blood cells and outline the main events that must occur within the cell to result in the formation of the red blood cell. [9]

[Total: 15]

VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2018
H1 BIOLOGY Paper 2 8876/2
Answers

Section A [45 marks]

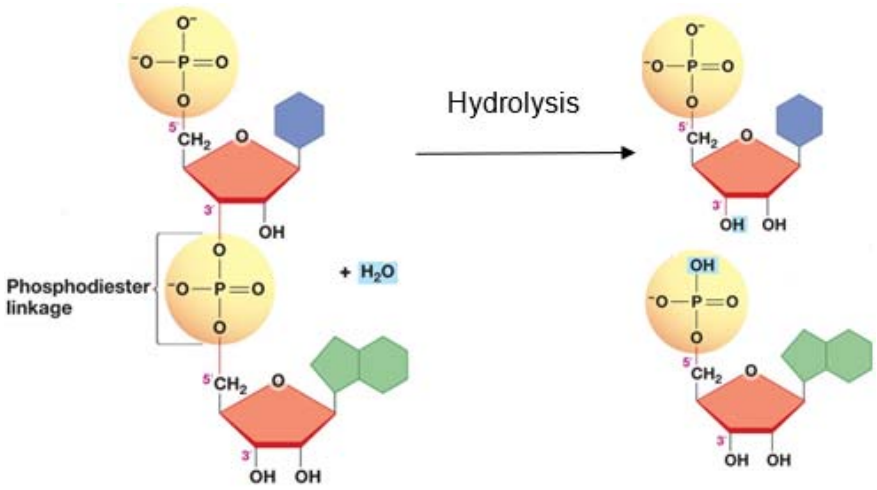
1 In eukaryotic cells, the degradation of mRNA is an essential part of the regulation of gene expression. It can be controlled in response to developmental, environmental, and metabolic signals. mRNA hydrolysis is catalysed by numerous types of nucleases, such as the endonuclease Ribonuclease A (RNAse A), shown in Fig. 1.1.



(A) Space-filling model (B) Ribbon diagram

Fig. 1.1

(a) Using a labelled and annotated diagram, illustrate the hydrolysis of the bond catalysed by RNAase.(A monomer has been drawn for you.) [2]



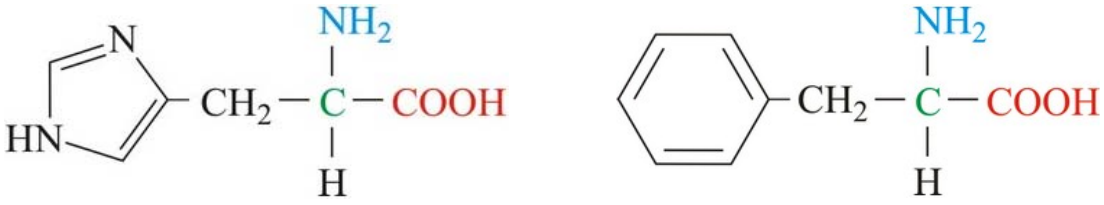
- Accurate drawing of mRNA strand, at least 2 nucleotides, allow legend / symbols;
- Accurate drawing of phosphodiester linkage + label;
- Water;
- Hydrolysis;
- Accurate drawing of nucleotides after hydrolysis;

Fig. 1.1B shows two important catalytic residues within the active site of RNAse A, which are His12 and His119.

(b) Explain how these two histidines, which are in position 12 and 119 of the 124 amino acid sequence, are brought together in the active site of the enzyme. [3]

- Primary structure + number, type and sequence of amino acid;;
- Determines how the polypeptide chain folds upon itself;
- To form the tertiary structure;
- Bringing faraway amino acids together within the active site;
- Stabilized by hydrogen, ionic, disulphide bonds and hydrophobic interactions;;

Fig. 1.2 shows the structure of histidine and phenylalanine.



(A) Histidine (B) Phenylalanine

Fig. 1.2

(c) Predict and explain how the catalytic activity of RNAse would be affected if both histidines were replaced by phenylalanines. [2]

- Histidine has an R-group that is polar whereas phenylalanine has an R-group that is non-polar;;
- This causes the change in the interaction between the catalytic residues and the substrate at the active site; therefore; RNAase catalytic activity will be greatly reduced / lost;;

Ribonuclease A is also the enzyme that digests RNA in our food. It is released by the pancreas of most mammals and some reptiles. Because is it small, stable, and easily purified, ribonuclease has been an important enzyme in biochemical research. In one procedure for purifying RNAse A from bovine pancreas, extracts are treated with sulfuric acid and then heated almost to boiling, leaving RNAse A as the only protein remaining intact.

(d) Suggest why RNAse A has such a stable structure and why it needs to be very stable. [2]

- Presence of disulfide linkages in tertiary structure; strong covalent bonds; resistant to pH changes;
- Idea of having to withstand harsh environment of digestive tract e.g. alkaline environment of small intestines;

2 Table 2.1 shows some mRNA codons and the amino acids for which they code.

amino acid	abbreviation	mRNA					
glutamic acid	glu	GAA	GAG	–	–	–	–
phenylalanine	phe	UUU	UUC	–	–	–	–
lysine	lys	AAA	AAG	–	–	–	–
proline	pro	CCA	CCC	CCG	CCU	–	–
threonine	thr	ACA	ACC	ACG	ACU	–	–
valine	val	GUA	GUC	GUG	GUU	–	–
cysteine	cys	UGC	UGU	–	–	–	–
arginine	arg	CGC	CGA	CGU	CGG	AGA	AGG

Table 2.1

Fig. 2.2 shows the sequence of three amino acids in the human lysozyme polypeptide.

amino acids	arg	cys	glu
tRNA	GC_/UCU/C	ACG/A	CUU/C
DNA	GC_/TCT/C	ACG/A	CTT/C

Fig. 2.2

(a) Use the information in Table 2.1 to fill in the possible tRNA anticodon and corresponding DNA sequence for each amino acid shown in Fig. 3.2. Write your answers in Fig. 2.2. [1]

(b) Explain what an “anticodon” is and its significance in the synthesis of proteins. [3]

- Sequence of 3 nucleotides on tRNA molecule;
- Complementary to mRNA codon;
- Genetic code unit;
- Codes for specific amino acid;
- Ensures correct amino acid is attached to tRNA to form aminoacyl-tRNA;
- Allows complementary base-pairing between mRNA and tRNA during translation;
- Ensures right amino acid is brought to ribosome for translation / Ensures that amino acids are in the right sequence as dictated by the mRNA sequence;

A student drew how DNA is replicated as shown in Fig. 2.3.

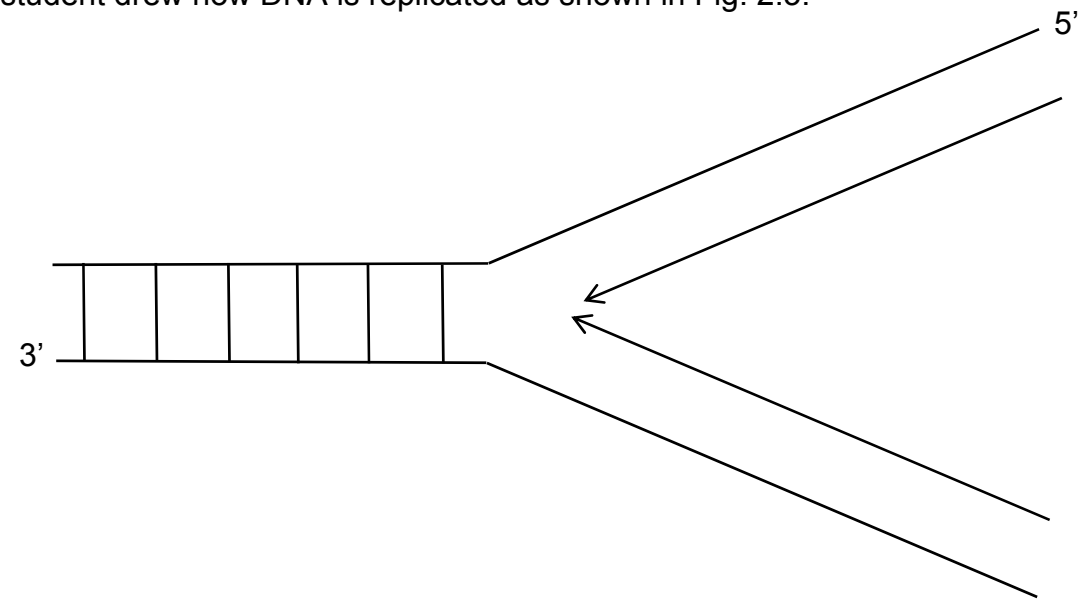


Fig. 2.3

(c) Evaluate the accuracy of the student’s drawing. [2]

- The 2 strands are not antiparallel;;
- Only one daughter strand should be synthesised continuously towards the replication fork;;
- The other strand is synthesized in a discontinuous manner in the form of Okasaki fragments;;
- Each Okasaki fragments is synthesized away from the replication fork;;
- Direction of synthesis of daughter strand should be from 5’ to 3’;;

3 (a) Structure **Q** in Fig. 3.2 is a cell structure which is involved in nuclear division.

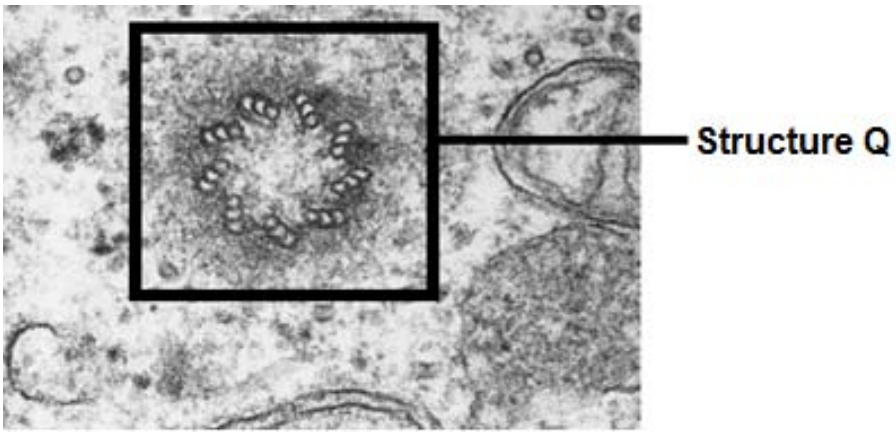


Fig. 3.2

(i) Identify structure Q and outline its role in nuclear division. [2]

- Centrioles;;
- Centrioles act as the microtubule-organising centres (MTOC) / involved in spindle fibre formation, help movement/separation of chromosomes;;

(ii) Compare the structure of Q and a ribosome. [3]

Similarities (at least 1):

- Both made up of protein subunits / contain amino acids;;
- Both lack membranes / not bound by membranes;;

Differences (at least 2):

- Q consists of 9 triplets of microtubules vs ribosome consist of 1 large and 1 small subunit;;
- Q lacks RNA vs ribosome has rRNA
- Q: protein subunits assemble to form linear microtubules vs ribosome protein subunits assemble to form overall spherical/globular shape

(b) Chickpeas may contain a lipase inhibitor that prevents the activity of the enzyme in the digestion of fats. There are two forms of lipase inhibitors – inhibitor **W** and inhibitor **X**.

Homozygous plants are known to produce one type of lipase inhibitor, depending on the allele which they are homozygous for.

A heterozygote plant with both types of alleles, on the other hand, will have two types of lipase inhibitor, inhibitor **W** and inhibitor **X**.

A third recessive allele does not code for any lipase inhibitor.

(i) State and explain the mode of inheritance for the lipase inhibitor in the chickpeas. [2]

- The type of **lipase inhibitor** is determined by **co-dominance**, since in the **heterozygous** condition, **both alleles are equally expressed**;;
- **Multiple alleles**, with the **3rd allele** being **recessive** to both inhibitor-coding alleles;;

A second character, seed texture, is controlled by another gene located on a different chromosome and is controlled by two alleles. Smooth seed-coat, **T**, is dominant over wrinkled seed-coat, **t**.

Two chickpea plants were crossed. One of them contains only inhibitor **X** and has smooth seed-coats. Their seeds were collected and counted, as summarised in Table 4.1.

Inhibitor(s) present in seed	Number of seeds	Seeds with smooth seed-coat / %
W and **X**	12	50
W	14	50
X	22	50

Table 3.1

(ii) Using suitable symbols, draw a genetic diagram to explain the results of this cross, as shown in Table 3.1. [5]

Let C^W be the (co)dominant allele that produces inhibitor W

C^X be the (co)dominant allele that produces inhibitor X

C^O be the recessive allele for that produces no inhibitor

T be the dominant allele for smooth seed-coat

t be the recessive allele for wrinkled seed-coat {1/2}

Parental phenotypes;	Inhibitor X, smooth coat	x	Inhibitors W and X, wrinkled coat
Parental genotypes;;	C^XC^OTt	x	C^WC^Xtt
		Meiosis;	
Gametes;;	C^XT C^Xt C^OT C^Ot	x	C^Wt C^Xt

Punnett square to show random fusion of gametes by the F_1 generation;

F1 genotypes:

♂ gametes / ♀ gametes	C^XT	C^Xt	C^OT	C^Ot
C^Wt	C^WC^XTt	C^WC^Xtt	C^WC^OTt	C^WC^Ott
C^Xt	C^XC^XTt	C^XC^Xtt	C^XC^OTt	C^XC^Ott

F1

Genotypic Ratio:	$1C^XC^XTt$	$1C^XC^OTt$	$1C^XC^Xtt$	$1C^XC^Ott$	$1C^WC^OTt$	$1C^WC^Ott$	$1C^WC^XTt$	$1C^WC^Xtt$;
F1 Phenotypic Ratio:	2 Inhibitor X & smooth seed-coat		2 Inhibitor X & wrinkled seed-coat		1 Inhibitor W & smooth seed-coat	1 Inhibitor W & wrinkled seed-coat	1 Inhibitor W & X & smooth seed-coat	1 Inhibitor W & X & wrinkled seed-coat;

[Total: 12]

4 In an experiment to investigate the effect of various environmental factors on seed germination, germinating soybeans were exposed to different temperatures and light intensities. Fig. 3.1 shows the experimental set-up.

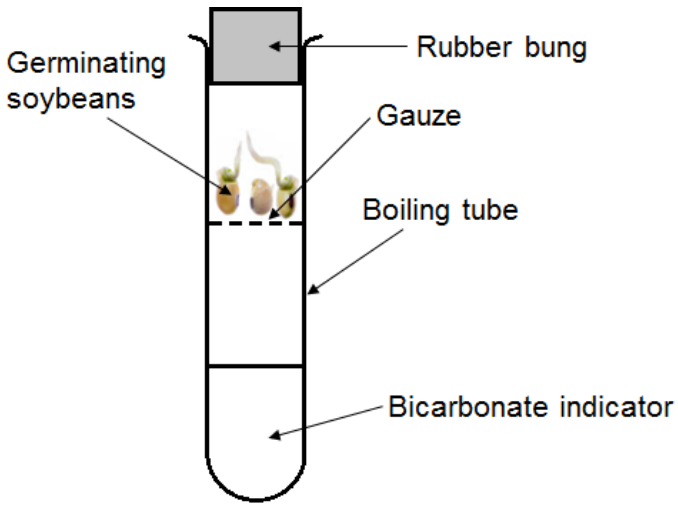


Fig. 4.1

Bicarbonate indicator is a pH indicator. It changes colours as the pH changes. At the start of the experiment, the bicarbonate indicator is at pH 7.

The set-up is left under different temperatures and light intensities for one hour, and the change in pH is recorded. Table 3.1 shows the results.

Temperature / ºC	Light intensity	pH of bicarbonate indicator after 1 hour
10	High	6.5
10	Low	6.5
20	High	6.0
20	Low	6.0
30	High	5.0
30	Low	5.0
40	High	4.5
40	Low	4.5

Table 4.1

(a) (i) Explain the reason for the drop in pH of the bicarbonate indicator. [2]

- Due to **increase in carbon dioxide concentration** as a result of **respiration** of germinating soybeans;;
- Carbon dioxide dissolves to form acidic solution, decrease pH;;

(ii) With reference to the information provided, explain the effect of light intensity on the germination of soybeans. [2]

- No effect + Q.V.;;
- Leaves have not been grown thus no photosynthesis;;

Studies on cancer cells found that fast-growing cancer cells require much more energy than normal cells, which explains the much higher rate of glucose uptake into cancer cells. However, it is also found that, unlike normal cells, the higher glucose uptake reduces oxygen uptake into cancer cells. This respiratory inhibition is known the Crabtree effect.

(b) (i) Besides the need for more energy for cell division, explain why cancer cells utilise glucose at a much higher rate than normal cells to produce energy. [2]

- Ref. to cancer cells having to resort to anaerobic respiration;
- Ref. to glycolysis; producing 2 net ATP per glucose oxidised;
- Ref. to cancer cells having to oxidise more glucose to produce enough ATP to sustain themselves;

(ii) Compare the differences between respiration in cancer cells and yeast cells. [1]

	Cancer cells	Yeast cells
Type of fermentation;;	• Lactate fermentation	• Alcoholic fermentation
Products (besides ATP);;	• Lactate / Lactic acid	• Ethanol and carbon dioxide
Enzyme(s) involved;;	• Lactate dehydrogenase	• Pyruvate decarboxylase and alcohol dehydrogenase

(c) Explain why ATP is regarded as the universal energy currency. [2]

- Found in all organisms;;
- Loss of phosphate / hydrolysis, leads to, energy release / release of 30.5 kJ (per mole);;
- ADP + Pi → ATP / reversible reaction;;
- Small / water soluble, so can move around cell;;
- Link between energy yielding and energy requiring reactions / AW;;
- Example of use e.g. active transport / muscle contraction / Calvin cycle / protein synthesis;;

[Total : 10]

5 It is predicted that by year 2100, global warming may be a lot more severe than expected should greenhouse emissions continue to proceed at the current rate. Global temperatures can potentially increase by as much as 5^{o}C.

Insects are known to be sensitive to temperature changes and they face risks associated with global warming. A study conducted on 50 fruit flies suggested that limiting global warming to 1.5^{o}C would save the vast majority of the world's insect species from climate change.

(a) Outline how global warming can impact insects negatively. [2]

- They are **ectotherms**;
- they **rely on environmental (or external) heat source** to increase their body temperature;
- Increase in temperature can **increase metabolic rate**;
- Increase metabolic rate can result in **changes in growth and developmental timing of insects**;
- They may **mature into adult insects** with a **smaller body size**;
- Therefore, decreases their chances in mating (especially for the male insects) → **fitness decreases**;
- Increase temperature may **exceed the thermal limits**;
- Especially in **insects with narrow temperature tolerance limit**;
- Resulting in **population decline and possible extinction events**;
- Global warming can lead to **extreme weather events**;
- Such as **heat waves and heavy rainfalls**;

- **Depress flight and decimate migrating insects**;
- **Delay mating** seasons → resulting in **population decline**;

Reducing the risk to insects is particularly important, the research team say, as the effect of climate change on them can potentially implicate human beings.

(b) Suggest how the impact of climate change on insects can potentially implicate humans. [2]

- Insects are important **pollinators** (eg. bees);;
- Without them, may have a **decrease in food supply** for humans

- Insects are **vectors for viruses** (eg. mosquito);;
- Shorter life cycles → increase in maturation of insects → more vectors to spread diseases OR Increase rainfall → more stagnant water for insects such as mosquitoes to breed) → more vectors to spread disease

Some scientists, however, believe that insects could evolve to become more heat-tolerant in the future.

(c) Explain how natural selection may lead to the evolution of more heat-tolerant insect species. [4]

- Variation in existing population; e.g. due to random mutations;
- Ref. to increasing temperature / global warming as selection pressure;
- Those that are more heat-tolerant e.g. have more thermostable enzymes are at selective advantage;;
- Will survive, reproduce and pass on favourable alleles to offspring;;
- Allele frequency for heat tolerance increases (microevolution);;
- Ref. to reproduction isolation + evolution of new species;;

[Total: 8]

Section C [15 marks]

Answer **one** question in this section. Each question has a part (a) and part (b).

Write your answers on the writing paper provided, with each part on a fresh sheet of paper.

Your answers should be in continuous prose, where appropriate.

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

6 (a) The Taq polymerase is a thermostable DNA polymerase named after the thermophilic bacterium ***Thermus aquaticus*** from which it was originally isolated from.

With reference to different levels of protein structure, explain how it is possible for both human DNA polymerase and the Taq polymerase to act on the same substrates, but for the Taq polymerase to have a higher optimum temperature [6]

- Definition of primary structure;;
- Ref to slightly different primary structure btw the two enzymes;;
- Number, sequence and type of amino acids that form the active site conformation largely the same;;
- such active site conformation is the same for both enzymes, complementary to same substrate, thus can act on same substrate;;
- More cysteine residues in primary structure of Taq polymerase;;
- More disulfide (covalent) bonds stabilizing its tertiary structure;;
- Definition of tertiary structure;;
- Requires more energy to break, thus higher optimum temp;;

(b) Explain, using examples, the significance of the fluid mosaic model to the functions of membranes at the cell surface or within cells. [9]

Definition of fluid mosaic model

1. Fluid – Individual phospholipid and protein molecule able to move laterally along the membrane;;
2. Mosaic – (Integral and peripheral) Proteins scattered in 'patchwork' arrangement in membrane;;

Significance of membrane fluidity [2 max for each point, 4 max in total]

3. Fluidity allows vesicles to fuse with the membrane;;

a. Fusion of secretory vesicles to cell surface membrane in exocytosis;;

b. E.g. Release of digestive enzymes / insulin / glucagon / etc.;;

c. Fusion of transport vesicles to cis face of Golgi apparatus;;

d. Transport of proteins from rough endoplasmic reticulum to the Golgi apparatus via transport vesicles;;

4. Fluidity allows membrane to pinch off to form vesicles;;

a. Invagination of cell surface membrane allows endocytosis;;

b. E.g. Phagocytosis of pathogens by white blood cells / etc.;;

c. Budding of membrane of rough endoplasmic reticulum packages proteins into transport vesicles;;

d. Budding of membrane of trans face of Golgi apparatus packages proteins into secretory vesicles;;

Significance of proteins scattered in the membrane [2 max for each point, 4 max in total]

5. Proteins scattered in membrane serve as transport proteins;;

a. Channel / Carrier protein for facilitated diffusion;;

b. Protein pump for active transport;;

6. Proteins scattered in membrane serve as enzymes;;

a. ATP synthase in inner mitochondrial membrane / thylakoid membrane;;

b. Digestive enzymes inserted in the cell surface membrane of epithelial cells in duodenum;;

7. Proteins scattered in cell surface membrane serve as receptors for cell signalling;;

a. E.g. receptor for growth signals / insulin receptor / glucagon receptor / AVP;;

8. Proteins scattered in cell surface membrane serve as cell markers for cell-cell recognition;;

9. Proteins scattered in inner mitochondrial membrane / thylakoid membrane serve as electron carriers;;

a. Arranged in decreasing energy levels to form the electron transport chain;;

b. Set up the high proton concentration in the intermembrane space / thylakoid space;;

c. Set up the high proton gradient / proton motive force across the inner mitochondrial membrane / thylakoid membrane;;

QWC

Answer that includes all 3 sections, and both membranes at the cell surface and within cells;;

7 (a) Explain how genes are inherited from one generation to the next via the germ cells or gametes. [6]

- **Genes are carried on chromosomes** in the cells of each individual;;
- Every **diploid** organism has **2 sets of chromosomes** per cell;;
- Parent cell passes 1 set of chromosomes / half number of chromosomes to gametes / formation of **haploid gametes**;;
- via **meiosis**;;
- **Fusion of gametes** to restore diploid number / form new individual;;
- **Genetic variation** may be introduced to next generation;;

- **Crossing over** during meiosis give rise to variations;;
- **Independent assortment and segregation** give rise to variations among gametes;;
- **Random mating** between individuals;;
- **Random fertilisation of gametes**;;

(b) Bone marrow contains many stem cells. Some of these stem cells are responsible for the replacement of red blood cells. During the production of red blood cells, a series of changes occur to the cell structure.

Describe the features of the stem cells responsible for production of red blood cells and outline the main events that must occur within the cell to result in the formation of the red blood cell. [9]

Features of stem cells

1. Blood stem cells are capable of making **identical copies of themselves via mitotic cell divisions** for the lifetime of the organism
2. as they have **active telomerase** that helps keep the telomere long so that the telomeres do not reach a critical length that will trigger apoptosis of the cell.
3. Due to their ability to undergo **long term self-renewal**,
4. they can play the important function of **continually making new red blood cells** (RBC) for the lifetime of the organism as red blood cells live for only three months (ref to **short life span of RBC**)
5. Blood stem cells are **unspecialised** and are able to give rise to specialised cell types under appropriate conditions
6. Blood stem cells are **multipotent** and have the ability to differentiate into a limited range of cell types (and are not pluripotent or totipotent) such as RBCs and immune cells.

Main events in cell to form RBC

7. A blood stem cell has the same genome as all the other somatic cells that are part of tissues, organs and systems in the body.
8. **Specific expression of different sets of genes** is required to produce proteins that will direct particular development of the cell into a red blood cell must take place.

9. By initiating transcription for a specific sets of genes such as the haemoglobin gene, the cell can differentiate into a RBC that is packed with **haemoglobin** molecules to **allow the RBC to carry its function of transporting oxygen** to different cells throughout the body.
10. ref to loss of organelles such as ribosomes, mitochondria
11. ref to loss of nucleus
12. ref to change in cell shape to a biconcave shape (due to changes in cytoskeleton)

QWC

Answer that includes at least one feature that's responsible for RBC production + at least 2 main events;;