

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2018

NAME	:	 	
CT CLASS)		

H2 BIOLOGY

9744/02

Paper 2 Structured Questions

2 hours

READ THESE INSTRUCTIONS FIRST

Write your Name and CT Class on the cover page of this paper.

Write in dark blue or blue pen.

You may use a soft pencil for any diagrams or graphs.

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

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

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

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

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

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

This document consists of 21 printed pages, including cover page.

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) Using a labelled and annotated diagram, illustrate the hydrolysis of the bond catalysed by RNAase.

(A monomer has been drawn for you.)



Fig. 1.1 B 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]

Fig. 1.2 shows the structure of histidine and phenylalanine.



(A) Histidine





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



2 Penicillin belongs to a group of antibiotics known as β lactams, which all act in the same way on bacteria.

Fig. 2.1 shows the membrane structure of a gram-positive and gram-negative bacteria.



Fig. 2.1

- (a) Based on your understanding of penicillin and with reference to Fig. 2.1,
- (i) deduce whether penicillin is more effective against gram-positive or gram-negative bacteria.

(ii) suggest a reason for your answer in (a)(i).

(b) One of the ways in which a bacterium may be resistant to an antibiotic, such as a β lactam, is by having protein pumps in its cell surface membrane which expel the antibiotic from the bacterium.

The structure of the bacteria efflux pump is shown in Fig. 2.2.



Fig. 2.2

The gene coding for such an efflux pump is carried on a plasmid.

(i) Outline how the bacterium produces an efflux pump from a gene on a plasmid.

[4]

High blood sugar levels increase the chances of bacterial infections in those with diabetes, hence control of blood glucose levels is important in to prevent blood infections in diabetics.

(ii) Describe one similarity between the bacteria efflux pump and the glucagon receptor that is important to their function.

......[1]

(iii) Suggest two ways the structure of the bacterial efflux pump is different from an insulin receptor involved in blood glucose regulation.

[4] [Total: 13] **3** Telomeres have a nucleotide sequence that is repeated as many as 2000 times. This repetition is shown in Fig. 3.1. Attached to the DNA of the telomere are protein units.



Fig. 3.1

(a) (i) What sequence of bases is repeated in the complementary polynucleotide shown in Fig. 3.1?[1] (ii) Suggest one reason for the presence of protein units in the telomere.[1] (b) In the past, repeating sequences were referred to as "junk DNA". Explain why the term "junk DNA" is misleading in the context of telomere.[2] (c) The repetitive base sequence of telomere DNA is an example of a non-coding base sequence. Explain what is meant by non-coding.[1]

(d) A study of individual telomere lengths and its correlation with age is shown in Fig. 3.2.



(Taken from https://www.wired.com/images_blogs/wiredscience/2011/05/telomere_graph.jpg)

Fig. 3.2

Account for the trend line shown in Fig. 3.2.

[4] [Total: 9] 9

4 (a) Explain why ATP is regarded as the universal energy currency in organisms.

.....

-[2]
- (b) 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. It is proposed that this is due to more mitochondrial damages in cancer cells.
- (i) Besides the need for more energy for cell division, explain the process how cancer cells utilise glucose at a much higher rate than normal cells to produce energy.

(ii) Compare the differences between respiration in cancer cells and yeast cells. [2]

- 5 lac operon consists of a promoter, an operator, a catabolite activator protein (CAP) binding site and structural genes such as lacZ which codes for β-galactosidase, an inducible enzyme. The operon switches on or off depending on the type of carbon source present.
 - (a) Define the term "inducible enzyme", with respect to β -galactosidase.

.....[1]

(b) An experiment was conducted to determine the identity of Substance X and Substance Y. Both substances are known to have an effect on the expression of β-galactosidase in *Escherichia coli*. Substance X was added after 10 minutes, Substance Y was added after 20 minutes and both substances X and Y were added after 30 minutes. The results are shown in Fig. 5.1.



Fig. 5.1

With reference to Fig. 5.1,

(i) suggest the identities for Substance X and Substance Y.

 (ii) explain how the expression levels of β -galactosidase are affected by Substance X and Substance Y between 10 minutes to 40 minutes.

 (c) In another experiment, the *trp* operon and the *lac* operon of a bacteria cell were made to fuse together. The fusion process is illustrated in Fig. 5.2.





Suggest the condition(s) needed for β -galactosidase to be expressed in this strain of bacteria that carries the fused operon. Explain your answer.

[4]

[Total: 12]

- 6 Some hormones circulating in the blood are able to trigger transcription within a cell, even though they are unable to enter the cell. Phosphatases and kinases then take part in cell activities that eventually result in genes switching on and transcription beginning.
 - (a) Suggest why the hormones, referred to in the passage, are unable to enter the cell.

.....[2]

(b) Use the information in the passage to outline the process of cell signalling.

[3]

- (c) Explain the role of the following in cell signalling.
- (i) Phosphatases

......[2]

(ii) Kinases

.....[2]

[Total: 9]

7 Chickpeas may contain a lipase inhibitor that prevents 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, on the other hand, will two types of lipase inhibitor, inhibitor \mathbf{W} and inhibitor \mathbf{X} . A third recessive allele does not code for a lipase inhibitor.

(a) Identify whether the inheritance of lipase inhibitor shows continuous or discontinuous variation. Give a reason for your choice.

(b) 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. Their seeds were collected and counted. One of the parental chickpea plants is found to contain only inhibitor X and has smooth seed-coats. The progeny of the dihybrid cross is summarised in Table 7.1.

Table 7.1			
Inhibitor(s) present	Number of seeds	Seeds with smooth	
in seed		seed-coat / %	
W and X	12	50	
W	14	50	
X	22	50	

With reference to Table 7.1,

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

 (ii) using suitable symbols, draw a genetic diagram to explain the results of this cross.

- [5]
- (c) Observed results of the above genetic cross differ from the expected results.

Suggest two reasons why such a discrepancy occurs, referring only to events that occur after meiosis.

.....[2]



(d) Structure **Q** in Fig. 7.2 is a cell structure which is involved in nuclear division.



Identify structure Q and describe its behaviour during meiosis.

8

(b) In order to deduce the evolutionary relationships between different mammalian species, the amino acid sequence of a segment of the H1 histone protein is analysed and compared. Fig. 8.1 below shows the comparison.

Histone H1 (residue 120-180)

HumanKKASKPKKAASKAPTKKPKATPVKKAKKKLAATPKKAKKPKTVKAKPVKASKPKKAKPVKMouseKKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKAKKPKVVKVKVKPVKASKPKKAKTVKRatKKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKAKKPKAVKVKPVKASKPKKAKTVKCowKKAPKPKKAASKAPAKKPKATPVKKAKKKTAATPKKTKKPKKVKPKPVKASKPKKTKKVKChimpanzeeKKASKPKKAASKAPTKKPKATPVKKAKKKLAATPKKAKKPKTVKAKPVKASKPKKAKPVK

	Human	Mouse	Rat	Cow	Chimpanzee
Human		6	6	8	0
Mouse	6		1	8	6
Rat	6	1		8	6
Cow	8	8	8		8
Chimpanzee	0	6	6	8	

Number of differences in the amino acid sequence of Histone H1

Fig. 8.1

With reference to Fig. 8.1,

(i) state, with reasons, the species that is most closely related to mouse.

.....[2]

(ii) construct a phylogenetic tree to show the evolutionary relationships between the species.

[2]

(c) Explain how the amino acid sequences in Fig. 8.1 supports Darwin's theory of evolution.

(d) Describe a modification to the investigation in (b) to deduce the evolutionary relationships between the mammalian species and *E. coli*.



(e) Biologists have disagreed over the evolutionary relationship between turtles and other reptiles, with morphological and molecular comparisons giving different results. Biologist studying morphological evidences used the absence of temporal openings in the skull of turtles as a shared derived character to construct the phylogenetic tree shown in Fig. 8.2. However, Biologists studying DNA sequences have constructed a different phylogenetic tree as shown in Fig. 8.3.





Fig. 8.3

With reference to the information given above,

(i) Explain the advantages of molecular methods in reconstructing phylogenetic relationships.



(ii) Explain why reptiles do not constitute a monophyletic grouping.

.....[2]

[Total: 15]

9 Macrophages are large phagocytic cells that are found in many tissues including alveolar tissue in the lungs. They provide the main means of defence against pathogens in this tissue. Fig. 9.1 is a drawing made from an electron micrograph showing part of a capillary and two alveoli, with a macrophage.





(a) Explain how macrophages function to protect the lungs from becoming infected.

[4]

(b) Macrophages are antigen presenting cells (APCs). Antigens from pathogens are presented to helper T-lymphocytes as shown in Fig. 9.2.



Fig 9.2

Very few helper T-lymphocytes respond to the presence of APCs by binding in the way shown in Fig. 9.2. Suggest why this is so.

(c) During an immune response, cells divide by mitosis. Describe how mitosis is involved in an immune response.

[3]

	Acquired	Natural
Active		
Passive		
		[4]

(d) Complete the table to indicate how the following types of immunity can occur.

L '.

[Total: 13]

----- End of paper -----