	VICTORIA JUNIOR COLLEGE JC 2 PRELIMINARY EXAMINATION 2018
NAME :_ CT CLASS:_	

Paper 3	Long structured and free-response questions	2 hours

9744/03

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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.

Section A

H2 BIOLOGY

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

Section B

Answer any **one** question.

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.

	For Examin	er's Use
The number of marks is given in brackets [] at the end of	1	
each question or part question.	2	
	3	
	Section B	
	Total	

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

Section A

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

1 Pneumonia is disease caused by the gram-positive pneumococcal bacteria. Pneumococcal infections result in an inflammatory condition of the lung affecting primarily the small air sacs known as alveoli. Hence, the symptoms of pneumonia include dry cough, chest pain, fever, and difficulty in breathing.

Pneumonia affects approximately 450 million people globally (7% of the population) and results in about 4 million deaths per year. Up to 40% of these infections were caused by pneumococcal bacteria that were resistant to at least one antibiotic.

Due to the severity of pneumonia and the rise in antibiotic resistance among bacteria, vaccines have been developed to protect individuals against the disease.

(a) Evaluate the effectiveness of vaccines against the rise of antibiotic-resistant strains of pnemococcal bacteria.

[4]

With the continuing threat of antibiotic resistance, bacteriophage therapy is employed as a mean to treat bacterial infections.

(b) Describe how a typical T4 bacteriophage can work against an antibiotic-resistant bacterium.

(c) A subset of the bacteriophage population, termed as "superspreaders", is observed to release substantial amounts of intact, transformable bacteria plasmid DNA along with the release of its progeny from the host.

These plasmid DNA molecules, however, are not found within the nucleocapsid of the bacteriophages.

These "superspreaders" are deemed to have the potential to promote antibiotic resistance among bacteria.

The use of antibiotics instead of decreasing numbers appears to increase the numbers of antibiotic resistance bacteria.

(i) Using the information given, describe how a bacterium could have acquired antibiotic resistance due to the release of such plasmid DNA.

.....[2]

(ii) Suggest how this could lead to an increase in the proportion of bacteria with antibiotic resistance in the population.

T4 bacteriophages generally contain phage-encoded endonucleases. The phageencoded endonucleases serve to hydrolyse the bacteria chromosome. It is hypothesised that the "superspreaders" may lack hydrolytic endonucleases, hence are able to release intact plasmid DNA during exit from the host cell.

A group of researchers decided to carry out an experiment on two strains of "superspreaders", namely SUSP1 and SUSP2, as well as T4 bacteriophage.

The 3 types of viruses are then exposed to *Escherichia coli* bacteria containing a chromosomal DNA molecule and an extra-chromosomal 130bp plasmid DNA molecule. In the control setup, the bacteria are not exposed to any virus.

Fig.1.2 shows the result of the experiment.



(d) Briefly comment on the validity of the hypothesis based on the results shown in Fig. 1.2.

To further confirm their hypothesis, researchers decide to amplify the genome of the three viruses and run a gel electrophoresis.

(e) As a good Biology student, name and describe a procedure that the researchers should undertake to determine the presence or absence of the hydrolytic endonucleases in the "superspreaders".

[4]

With climate change, environmental scientists predict that there will be a surge in the emergence of new viral and bacterial infectious diseases to the current human population.

(f) Besides mutation, suggest how the environmental scientists' prediction might come true.

.....[1] [Total: 20] 2 The mitotic cell cycle consists of a sequence of carefully orchestrated events that a cell passes through between one division and the next. It is tightly regulated to ensure that cells will only undergo division when conditions are optimal.





Fig. 2.1 (modified from <u>https://mrrittner.weebly.com/unit-4-cell-cycle.html</u>)

(a) (i) On Fig. 2.1, label and name two critical positions where a cell can be regulated in the mitotic cell cycle. [2]

(ii) Explain the significance of the critical positions labelled in (a) (i) to the regulation of the cell cycle.

Position 1	 	 	 	
Position 2	 	 	 	
	 	 	 	[4]

Dysregulation of cell cycle leads to cancer.

Skin cancer cells may be grown in culture and examined using the technique of immunofluorescence in which antibodies are used to attach fluorescent dyes to specific molecules within the cells.

Fig. 2.2 is an immunofluorescent light micrograph of skin cancer cells. There are two cells in the process of nuclear division, one of which has areas stained with two different fluorescent dyes, labelled **A** and **B** on Fig. 2.2.



Fig. 2.2

(b) Identify the two areas labelled A in the dividing cell in Fig. 2.2 and outline their function.

(c) Before the skin cancer cells could be stained with antibodies, the cells had to be fixed and treated with a mild detergent to increase the permeability of the cell surface membranes.

(i) Explain why it is necessary to increase the permeability of the cell surface membranes before staining cells using the technique of immunofluorescence.

(ii) Suggest one advantage of using immunofluorescence to study the changes that occur in cells during cell division.

.....[1]

Scientists have detected telomerase activity in more than 90% of human tumour samples. Recent advances in reprograming somatic cells into induced pluripotent stem cells (iPSCs) showed that these cells also express high levels of telomerase, behaving like embryonic stem cells. Research on these iPSCs showed that they are able to provide functional neuronal cells, blood cells, and retinal cells, which would be a useful source for transplantation.

(d) (i) Explain why embryonic stem cells do not give rise to tumour.

(ii) Discuss one ethical concern that iPSC research attempts to address.

......[2] [Total: 17]

- **3** Lizards are ectotherms. They bask in the sun to warm up when environmental temperatures are cool and stay in the shade when the temperatures get too hot. They are susceptible to negative effects of rising temperatures and can forage for food only when environmental temperatures are favourable for activity.
 - (a) Explain why ectotherms are "susceptible to the negative effects of rising temperatures".

A lizard's foraging time is limited to the part of the day when it can warm its body in the sun (when the lizard is too cold) and cool its body in the shade (when the lizard is too hot). Global warming will thus affect this foraging time.

Fig. 3.1 shows the change in the lizard's *operative temperatures* (its body temperature while it is at rest) over the course of a spring day before global warning (A) and after (B).

The top line graph shows the change in operative temperature in full sun (maximum operative temperature) while the bottom line graph shows the change in operative temperature in shade (minimum operative temperature).



The light band defines the temperature range suitable for activity.



(b) With reference to Fig. 3.1, account for two effects of global warming on the lizard's foraging period.

Scientists, Barry Sinervo and colleagues, studying the effects of global warming on the lizard populations in Mexico, predicted that they will go extinct, partly due to the effect of high temperature on their foraging activity.

(c) Explain why the change in the foraging activity due to increased temperatures can lead to the extinction of the local lizard populations.



The scientists also studied two types of lizards – one viviparous (live bearing), the other oviparous (egg laying) and predicted their probability of extinction due to global warming.

Fig. 3.2 shows the predicted probability of extinction of the two lizard species against the difference in elevation from the midpoint of their geographic range (demarcated 0).





(d) Justify the predictions made by the scientists as shown in Fig. 3.2.

(e) Suggest how the live-bearing and egg-laying lizards evolved to become different species from a common egg-laying ancestor.

[4] [Total: 13]

Section B

Answer one question in this section.

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

Your answers must be in continuous prose, where appropriate.

Your answer must be set out in parts (a) and (b), as indicated in the question.

- 4 (a) Compare the differences between B and T lymphocytes and describe how cell signalling helps B lymphocytes to play a role in the production of high-affinity antibodies with different effector function. [13]
 - (b) Describe how bacteria reproduce asexually and suggest advantages of such a process. [12]

[Total: 25]

5 (a) Environmental factors affect the phenotype of organisms. For example, fur colour of Himalayan rabbit is affected by temperature.

Explain the significance of the environment on variation and the formation of new species. [13]

(b) The Polymerase Chain Reaction (PCR) was a revolutionary method developed by Kary Mullis in the 1980s.

Outline the main principles of PCR and discuss how DNA replication by PCR differs from the process of how lambda phage replicates its genome via a lysogenic cycle within its host cell. [12]

[Total:25]