Name:	Centre/Inde	x Number:	Class:
* SINGAPORE	DUNMAN HIGH SC Preliminary Examir Year 6	HOOL nation	

# **H2 BIOLOGY**

Paper 2 Structured Questions

# 9744/02

15 September 2023 2 hours

#### READ THESE INSTRUCTIONS FIRST:

Write your centre number, index number, name and class at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, 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 appropriate units.

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

For Examiner's Use	
1	13
2	11
3	9
4	9
5	12
6	11
7	9
8	9
9	8
10	4
11	5
Total	100

This document consists of 33 printed pages and 3 blank pages.

#### **Section A: Structured Questions**

Answer **all** questions.

#### **Question 1**

Capillaries are the smallest blood vessels in humans. Their very thin walls are made of endothelial cells, across which nutrients and cells may pass selectively.

Fig 1.1 shows a cross section of a human capillary, with some blood cells found in its lumen.





(a) Explain how the cross section of a human capillary in Fig 1.1 supports the cell theory.

[2]

# **BLANK PAGE**

3

An experiment was carried out to study the synthesis and movement of proteins within macrophages.

Fig 1.2 shows the method used.



Table 1 shows the results of this experiment.

Table 1

	Level of radioactivity / arbitrary units		
Time / minutes	Ribosomes	Cisternal space of rough endoplasmic reticulum	Golgi apparatus
5	60	0	0
10	80	40	0
15	20	50	0
20	15	50	10
25	10	20	30
30	5	20	60
35	5	10	40
40	5	5	20
Total radioactivity	200	195	160

(b) Describe and explain the changes in the level of radioactivity in the ribosomes.

\_\_\_\_\_ [4]

(c) Suggest why the total radioactivity in the Golgi apparatus was lower than the total radioactivity in the ribosomes.



A macrophage is a type of phagocyte which engulfs bacteria during a bacterial infection. Fig 1.3 shows some processes that occur in a macrophage.



Fig 1.3

(d) (i) State two structural features of bacteria that are not found in a macrophage.

[2]

(ii) Phagocytes such as macrophages contain many lysosomes.

With reference to Fig 1.3, explain the functions of lysosomes.

[3]

Sorghum is a staple food in Africa. The major storage protein that it contains, kafirin, is not easily digested by protease enzymes. Upon heating, kafirin can undergo unfolding as shown in Fig 2.1.



Fig 2.1

(a) With reference to Fig 2.1, explain what determines the three-dimensional conformation of kafirin.



(b) Explain why an enzyme acts only on a specific substrate.

[2]

The digestibility of the protein in two varieties of sorghum (Macia and NK8828) was measured when raw, after cooking with and without acid. Digestibility was measured as the percentage of the protein that was broken down to amino acids during digestion.



The results are shown in Fig 2.2.



- (c) With reference to Fig 2.2, contrast
  - (i) the digestibility of raw and cooked sorghum,
    - [1]
  - (ii) the digestibility of cooked sorghum with and without acid.

[1]

(d) Account for the two differences described in (c)(i) and (ii).

[4]

Total: [11]

Fig 3.1 shows water and ion channels that are found in the cell surface membrane of all cells.



Fig 3.1a

Fig 3.1b

(a) Explain why these channels are necessary to allow movement of ions and water molecules across the cell surface membrane.

[3]

(b) With reference to Fig 3.1, describe how the mechanism of transport differs between the two channels.

[1]

Fig 3.2 shows the rate of transport against the concentration difference for the mode of transport shown in Fig 3.1a.





(c) (i) On Fig 3.2, draw the expected results for the rate of transport against the concentration difference for the mode of transport shown in Fig 3.1b.

[1]

- (ii) Explain your answer to (c)(i).
  [2]
  (d) Rate of transport involving the hydrolysis of ATP is expected to be constant regardless of concentration difference. Explain why.
  - [2]

Total: [9]

DNA fingerprinting is a method to identify an individual based on his/her DNA. In traditional DNA fingerprinting, DNA is first isolated from cells, and then amplified by Polymerase Chain Reaction (PCR). Fig 4.1 illustrates the process of PCR.



Fig 4.1

(a) (i) *Taq* polymerase is derived from *Thermus aquaticus*, a species of bacteria.



[2]

DNA fingerprinting is often used in paternity testing. This involves the investigation of Variable Number Tandem Repeat (VNTR) loci in the individual's genome. At least 13 VNTR loci are usually investigated in paternity testing to ensure accuracy. Fig 4.2 shows an example of samples from three individuals having different VNTR at a gene locus.



https://www.differencebetween.com/difference-between-vntr-and-vs-str/

#### Fig 4.2

A paternity test was conducted to identify the father of a child. Table 4 shows the genotype of five individuals at five different VNTR loci A, B, C, D and E. The numbers represent the number of repeats at the respective locus on each pair of homologous chromosomes.

I apre 4	Τa	ab	le	4
----------	----	----	----	---

Individual	VNTR locus				
Individual	А	В	С	D	Е
Mother	16, 16	15, 16	20, 22	13, 14	28, 30
Child	16, 18	16, 16	22, 24	13, 14	28, 29
Male 1	16, 18	16, 16	22, 23	14, 15	28, 31
Male 2	17, 18	15, 16	24, 25	11, 12	28, 30
Male 3	15, 18	16, 16	19, 24	12, 13	29, 31

(c) (i) State and explain who may possibly be the father of the child.

[2]

(ii) Explain why the paternity test above cannot conclude which male is the father of the child with absolute certainty.

[1]

Total: [9]

A population of Escherichia coli was grown on a culture medium containing a mixture of glucose and lactose for over four hours. The growth of *E. coli* over time is shown in Fig 5.1.



Fig 5.1

(a) (i) Explain why relative cell density increased faster when glucose was metabolised compared to when lactose was metabolised.



A particular strain of *E. coli* bacteria was spread throughout the surface of a nutrient agar plate. Four solutions, each containing different lytic phages (**A**, **B**, **C** and **D**), were then introduced into each quadrant of the agar, as shown in Fig 5.2.

The plate was incubated for 24 hours to allow bacterial cells to divide and grow into a lawn. Areas where bacteria were absent showed up as clear zones. Clear zones were observed only in the quadrant where phage **A** was introduced but was not observed in the other three quadrants.





(b) Explain how infection by phage **A** resulted in clear zones.

[2]

Colibacillosis is a fatal condition in poultry caused by a pathogenic strain of *E. coli*.

In a study to examine the effectiveness of bacteriophages in treating colibacillosis, broiler chickens were subjected to an aerosol spray containing bacteriophages on Day 0. They were then separated into five experimental groups, each being injected with the pathogenic *E. coli* on Day 0, Day 1, Day 2, Day 3 and Day 4, respectively.

A control group of chickens that were not treated with bacteriophages was also subjected to the same *E. coli* injection.



Fig 5.3 shows the death rate for the control group and experimental group on Day 21.

Fig 5.3

(c) (i) With reference to Fig 5.3, evaluate the effectiveness of bacteriophages in reducing death rate due to colibacillosis.



(ii) Suggest why the use of bacteriophages is a better alternative to antibiotic therapy for the chickens.

[1]

Total: [12]

## **BLANK PAGE**

Uncontrolled mitosis can cause cancer in humans. While some mutations occur spontaneously due to errors in DNA replication, others could be induced by environmental factors or biological agents.

(a) Explain four reasons why gene mutations may not always lead to cancer formation.

[4]

Multiple myeloma (MM) is a type of cancer in the bone marrow where some of the stem cells start to produce abnormal blood cells.

One treatment is to collect stem cells from the bone marrow of the person with MM. Healthy stem cells are isolated and grown in the laboratory. Chemotherapy is then used to destroy all stem cells and cancerous cells in the bone marrow. Finally, large numbers of the healthy stem cells grown in the laboratory are returned to the bone marrow.

(b) Explain the role of stem cells in this treatment of multiple myeloma.

[3]

Paclitaxel is a drug used in the treatment of some forms of cancer.

Researchers investigated the effect of Paclitaxel on the mitotic cell cycle of cancer cells:

- The cancer cells were grown for two days and then divided into groups.
- Each group was treated with a different concentration of Paclitaxel.

After 28 hours (one cell cycle):

- The percentage of cells in stages of mitosis was calculated.
- The ratio of the number of cells in anaphase to the number of cells in metaphase was determined.

Fig 6 shows the results of the investigation.



Fig 6

# (c) With reference to Fig 6,

(i) describe the effect of Paclitaxel on the mitotic cell cycle,



[2]

Total: [11]

The Labrador is a variety of domestic dog. Labradors have fur that are distinctly brown, black, or yellow.

In Labradors, there are two genes that primarily determine fur colour. *TYRP1* is one gene that codes for fur colour. This gene has two alleles, **B** and **b**.

- The dominant allele, **B**, codes for the enzyme tyrosinase that functions in the pathway to produce melanin, leading to black fur.
- The recessive allele, **b**, codes for an enzyme that results in the production of a brown form of melanin, leading to brown fur.

Another gene, *MC1R*, interacts with *TYRP1*. *MC1R* has two alleles, **E** and **e**.

- The dominant allele, **E**, allows the alleles of *TYRP1* to be expressed.
- The recessive allele, **e**, prevents the alleles of *TYRP1* from being expressed.
- When no form of melanin is produced, the Labrador will have yellow fur.

#### (a) (i) State the mode of inheritance of melanin production in Labradors.

		[1]
(ii)	State the genotypes of a brown dog.	
		[1]

(iii) A black male Labrador and a brown female Labrador were crossed to produce offspring with all three fur colours.

In the space below, construct a genetic diagram to show the ratio of offspring from this cross.

(b) With reference to the information provided, justify whether the variation of fur colours of Labradors is an example of continuous or discontinuous variation.

[3]

Total: [9]

# **BLANK PAGE**

Cotton, *Gossypium hirsutum*, and false flax, *Camelina sativa*, are crop plants that are grown in different parts of the world. Rubisco activase is an enzyme in the stroma of chloroplasts that is needed to maintain the activity of rubisco.

Fig 8.1 shows the activity of rubisco activase in cotton and in false flax over a range of temperatures.





(a) With reference to Fig 8.1, compare the activity of rubisco activase in cotton and false flax.



Rubisco activase catalyses the removal of inhibitory molecules, such as oxygen molecules from the active site of rubisco. When oxygen concentration is high, oxygen molecules can compete with carbon dioxide molecules for the active site of rubisco.

Fig 8.2 shows a process called photorespiration when oxygen molecules bind to the active site of rubisco.





(b) Explain two ways how photorespiration slows down the Calvin cycle.

[2]

The actual net number of ATP molecules synthesised for each glucose molecule respired in these crop plants was also measured.

Fig 8.3 outlines the main stages of aerobic respiration.





Modern research has shown that the oxidative phosphorylation of:

- one molecule of reduced NAD results in the synthesis of 2.5 ATP molecules
- one molecule of reduced FAD results in the synthesis of 1.5 ATP molecules.

At one time, it was previously thought that the theoretical number of ATP molecules synthesised for each glucose molecule respired was higher than this actual net number.

(c) (i) Calculate the net number of ATP molecules that are synthesised for each molecule of glucose respired in all phosphorylation reactions. Show your working.

Net number of ATP molecules: [2]

(ii) Suggest **two** reasons why the actual net number of ATP molecules synthesised is less than the theoretical number.

[2]

Total: [9]

Fig 9.1 shows the metabolic processes in the liver activated by two hormones, **P** and **Q**.





(a) Identify hormones P and Q.

P	
-	
Q	[2]

(b) Describe **three** similarities in the cell signalling pathways after the activation of cell surface receptors by the hormones.

[3]

Hormone **Q** is known to share a cell signalling pathway with another growth factor. Fig 9.2 shows the shared pathway.



Edited from Higashi, Yusuke & Sukhanov, Sergiy & Anwar, Asif & Shai, Shaw-Yung & Delafontaine, Patrice. (2012).

#### Fig 9.2

(c) Explain how the receptor is activated upon binding of hormone Q.

[2	2]

(d) The growth factor and hormone **Q** are structurally different, explaining the need to bind to different receptors with unique binding sites.

Suggest **one other reason** why the growth factor and hormone **Q** need to bind to different receptors.

[1]

Total: [8]

Since the discovery of antibacterial activity of penicillin in the 1920s, there has been a rise in emphasis on finding new antibacterial agents. Fig 10 shows the number of new antibacterial agents discovered from 1983 to 2004.



Fig 10

(a) Despite the discovery of more antibiotics, bacterial infections continue to pose a threat to public health.

With reference to Fig 10 and using your knowledge, explain why bacterial infections continue to be a looming public health crisis.



(b) Describe how normal bacterial flora is different from bacterial pathogens.

[1]

Total: [4]

Outline how an increase in temperature as a result of global warming can impact insects.

[5]
[0]

Total: [5]