H

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 2

CANDIDATE NAME			
BIOLOGY CLASS	2bi2___	REGISTRATION NUMBER	

BIOLOGY

9744/03

Paper 3: Long Structured and Free-response Questions **25 August 2023**

Candidates answer on the Question Paper and Answer Booklet **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and Biology class in the spaces 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.

Section A
Answer **all** questions in the spaces provided on the Question Paper.

Section B
Answer any **one** question in the Answer Booklet.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your workings or if you do not use appropriate units.

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

For Examiner's Use	
Section A	
1	**/30**
2	**/10**
3	**/10**
Section B	
4/5	**/25**
Total	**/75**

This document consists of **14** printed pages and **2** blank pages.

Section A

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

1 FoxO1 is a protein found in pancreatic β cells.

Fig.1.1 shows a model of FoxO1.

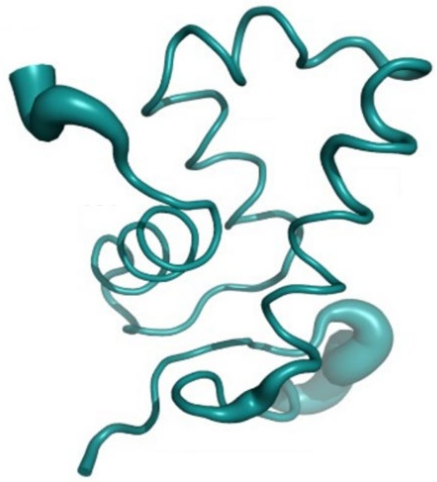

Fig. 1.1

(a) Describe how monomers may be linked together to form the FoxO1 polypeptide chain.

[2]

(b) Explain how amino acids that are spaced far apart in the FoxO1 polypeptide chain may be brought together in its 3-dimensional structure.

[4]

Diabetes is often associated with the failure of the β (beta) cells in the pancreas, but it is unclear what actually causes this failure. Some studies have suggested that this failure may be related to FoxO1.

A study was conducted using mice lacking the gene for FoxO1 in β cells (IKO) as well as normal (control) mice. Blood glucose levels after fasting were compared for four groups of mice: young (3 months old) male mice, young (3 months old) female mice, older females (who have had several pregnancies) and aging males (16–20 months). The results are shows in Fig. 1.2.

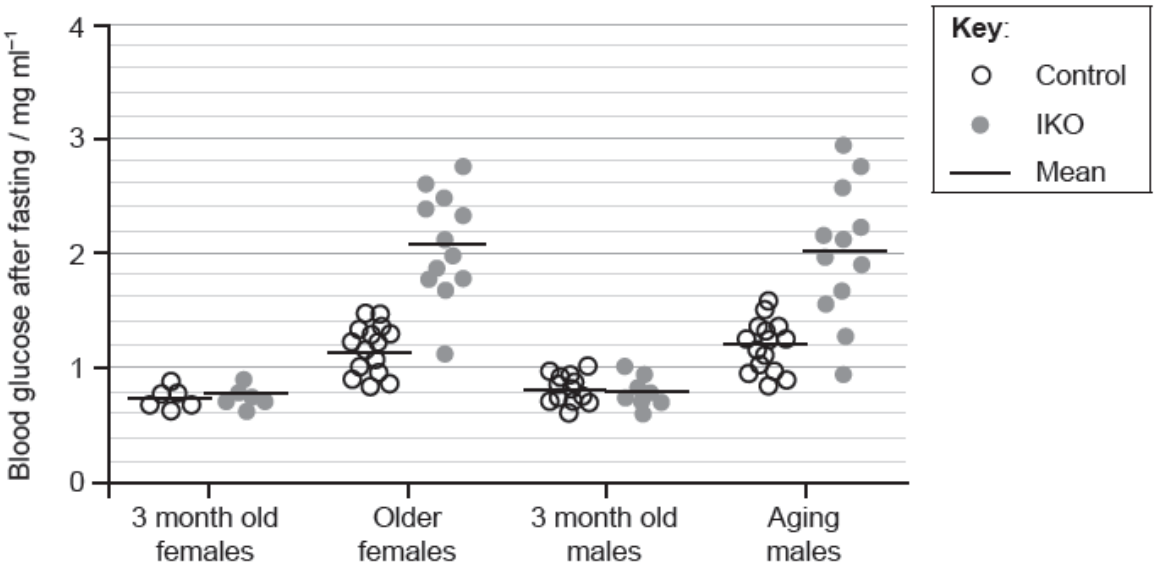

Fig. 1.2

(c) Describe and explain the blood glucose levels after fasting between young control mice and young IKO mice without FoxO1.

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..... [3]

(d) Aging and having pregnancies are considered to be physiological stresses.

Describe and explain the effect of stress on blood glucose levels in control mice.

[3]

(e) Insulin and glucagon are hormones that are synthesised by pancreatic cells and secreted into the bloodstream in response to changes in blood glucose concentration to maintain homeostasis.

Explain how such newly synthesised hormones are processed and released into the bloodstream by pancreatic cells.

[4]

The levels of pancreatic hormones and β cell mass in older female control mice and older female IKO mice lacking FoxO1 were then investigated. The results are shown in Fig. 1.3.

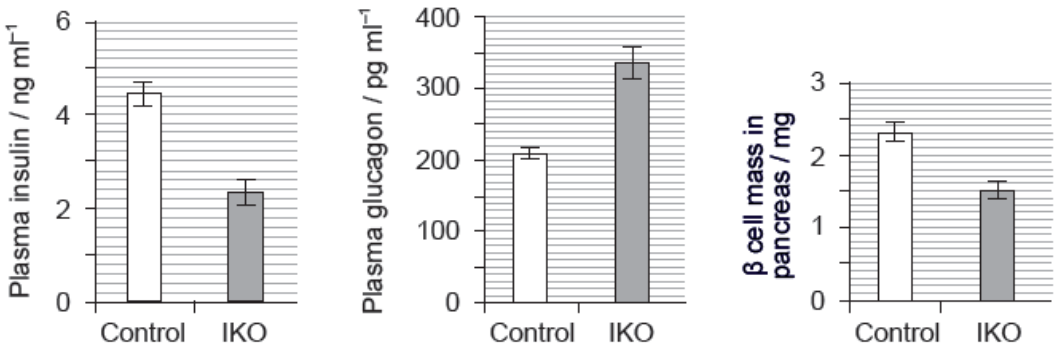

Fig. 1.3

(f) Calculate the percentage difference in β cell mass of the IKO mice compared to the control mice.

Show your workings and give your answer in **three** significant figures.

2

..... % [2]

(g) Outline the relationship between lack of FoxO1 and levels of pancreatic hormones in mice.

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..... [2]

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(h) Using information from Fig. 1.2 and Fig. 1.3, deduce the relative levels of pancreatic hormones in young female control and IKO mice lacking FoxO1

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..... [1]

To examine whether the changes observed were due to lack of β cell function or change in β cell number, investigators studied the following types of cells:

- still producing insulin
- newly formed β cells
- no longer producing insulin.

The results are shown in Fig. 1.4.

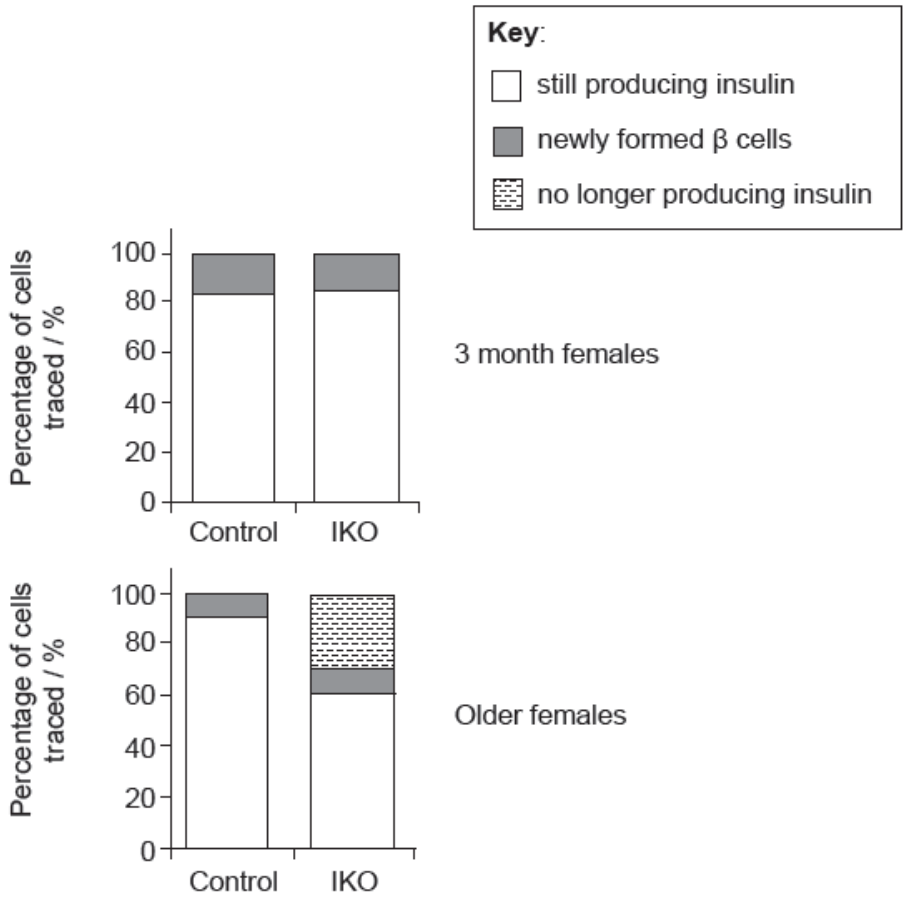

Fig. 1.4

(i) State which group of cells showed the least change in the mice studied.

.....

[1]

(i) Describe the effects of aging on the distribution of cell types in mice.

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[3]

(j) A hypothesis has been suggested that diabetes is caused by β cells losing their function, not by their death.

Discuss the extent to which the data in Fig. 1.3 and Fig 1.4 support this hypothesis.

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[3]

(k) When there are high blood glucose levels, more FoxO1 is found in the nucleus of the cell than in the cytoplasm.

Based on all the information provided, suggest a role for FoxO1.

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..... [2]

[Total: 30]

2 The HIV/AIDS epidemic in the 2000s has had a very large impact on life expectancy in many African countries.

Table 2.1 shows estimated data for four African countries for:

- the average life expectancy of an individual born in 2002
- the average life expectancy of an individual born in 2002 if there was no HIV/AIDS pandemic
- the percentage of the population testing positive for HIV in 2002.

Table 2.1

Country	Life expectancy / years		Percentage of population testing positive for HIV
	Without HIV/AIDS	With HIV/AIDS	
Kenya	65.6	45.5	14.0
Malawi	56.3	38.5	16.0
South Africa	66.3	48.8	19.9
Zambia	55.4	35.3	20.0

(a) Using the data shown in Table 2.1, calculate the percentage decrease in life expectancy for Zambia due to HIV/AIDS.

Show your workings and give your answer to the nearest **whole** number.

.....% [2]

(b) Evaluate if there is a correlation between the percentage of the population testing positive for HIV and percentage decrease in estimated life expectancy with HIV/AIDS.

[3]

(c) Explain the role gp120 and gp41 in the reproductive cycle of HIV.

[2]

(d) Following infection, $CD4^+$ T cells will synthesise new copies of gp120 and gp41.

Explain how cellular synthesis of gp120 and gp41 can lead to the destruction of infected $CD4^+$ T cells by the immune system.

[3]

[Total: 10]

Question 3 continues on page 11

3 Fig. 3.1 shows how sea surface temperatures have varied over the last century or so at the Great Barrier Reef. 0°C is considered as no change in the sea surface temperature. Rising sea surface temperatures have been suggested as a reason for more frequent coral bleaching events.

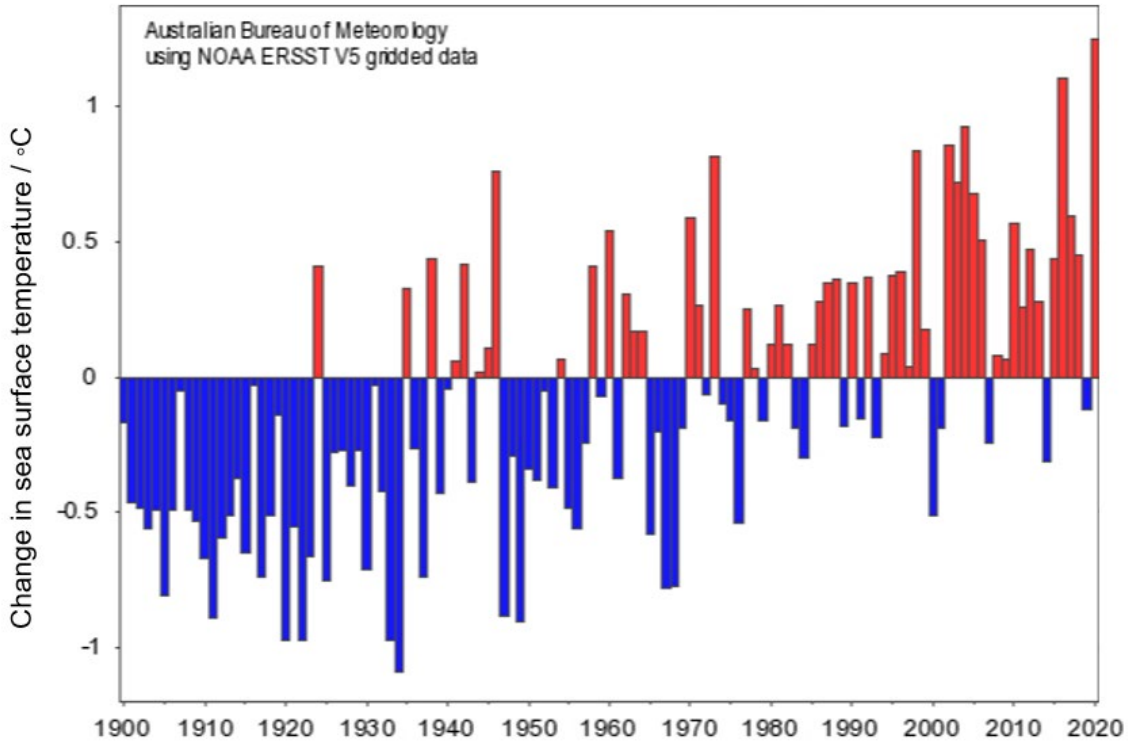

Fig. 3.1

(a) Explain how increase in sea surface temperature may lead to coral bleaching.

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[2]

Fig. 3.2 shows the trend for coral bleaching events globally since 1980.

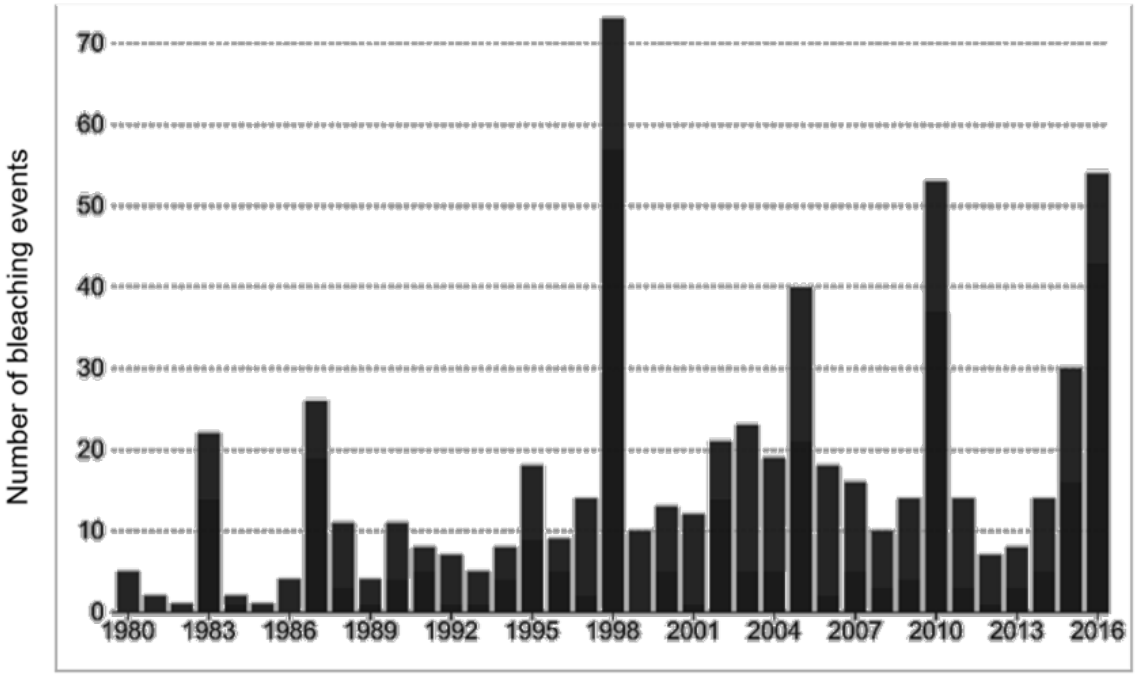

Fig. 3.2

(b) With reference to Fig. 3.1 and 3.2, evaluate if the data provides sufficient evidence that rising sea surface temperatures has led to an increase in frequency of coral bleaching events over the last 40 years.

[3]

(c) Other than rising sea surface temperature, climate change also leads to an increase in dissolved carbon dioxide in seawater.

Explain, with reference to biochemical details, the direct effects of increasing carbon dioxide on the rate of photosynthesis within corals.

[3]

(d) Suggest two other ways climate change can potentially affect growth of coral reefs.

[2]

[Total: 10]

Section B

Answer **one** question in this section.

Write your answers on the Answer Booklet 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 parts **(a)** and **(b)**, as indicated in the question.

4 **(a)** Describe how prokaryotes and mammals are able to detect and respond to changes in supply of sugars. [15]

(b) Discuss the advantages of the response of prokaryotes and mammals to changes in supply of sugars. [10]

[Total: 25]

5 **(a)** Describe how complementarity between biomolecules enable eukaryotic cells to carry out their diverse functions. [15]

(b) Discuss the advantages of having different degrees of complementarity between biomolecules in eukaryotic cellular processes. [10]

[Total: 25]