YISHUN INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAM
Higher 2

NAME

INDEX NO | CG

BIOLOGY

9744/03

Paper 3 Long Structured and Free-Response Questions

15 September 2023

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

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

Section B
Answer any **one** question in the spaces provided on the Question Paper.
Indicate the question you have attempted at the top of page **15**.

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	
Section A	
1	/30
2	/10
3	/10
Section B	
4 or 5	/25
Total	/75

Overall Results for H2 Biology Preliminary Examination				
Paper	**Raw Marks**	**Weighting (%)**	**Weighted score**	**Grade**
1	/30	15	/100	
2	/100	30	/100	
3	/75	35	/100	
4	/55	20	/100	

This document consists of **19** printed pages and **1** blank page.

Section A

Answer **all** questions in this section.

1 (a) Table 1.1 shows the incidence rates per 100 000 women for tuberculosis and breast cancer in Sweden from 2010 to 2020.

Table 1.1

year	incidence rate per 100 000 women per year	
	breast cancer	tuberculosis
2010	149	7.2
2012	157	6.6
2014	175	5.8
2016	179	5.1
2018	184	4.9
2020	188	3.5

Medical treatment, preventative measures, diet and lifestyle have changed over this time period and may account for the trends shown in Table 1.1.

(i) With reference to Table 1.1 and the information provided, suggest and explain a hypothesis that may account for the trends of each of the diseases shown in Table 1.1.

breast cancer .....

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tuberculosis .....

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..... [4]

[BLANK PAGE]

(ii) Explain why tuberculosis is considered an infectious disease while breast cancer is not.

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..... [2]

Epidemiological studies suggest that the incidence of cancer is associated with type 2 diabetes. Type 2 diabetes is a form of diabetes that is characterised by high blood sugar levels and insulin resistance, whereby cells do not respond properly to insulin. Type 2 diabetes is thought to be attributed to lifestyle factors.

One study in Sweden investigates the incidence rates of various types of cancer in people with and without type 2 diabetes from 1998 to 2013.

Fig. 1.1 shows some of the results of the study.

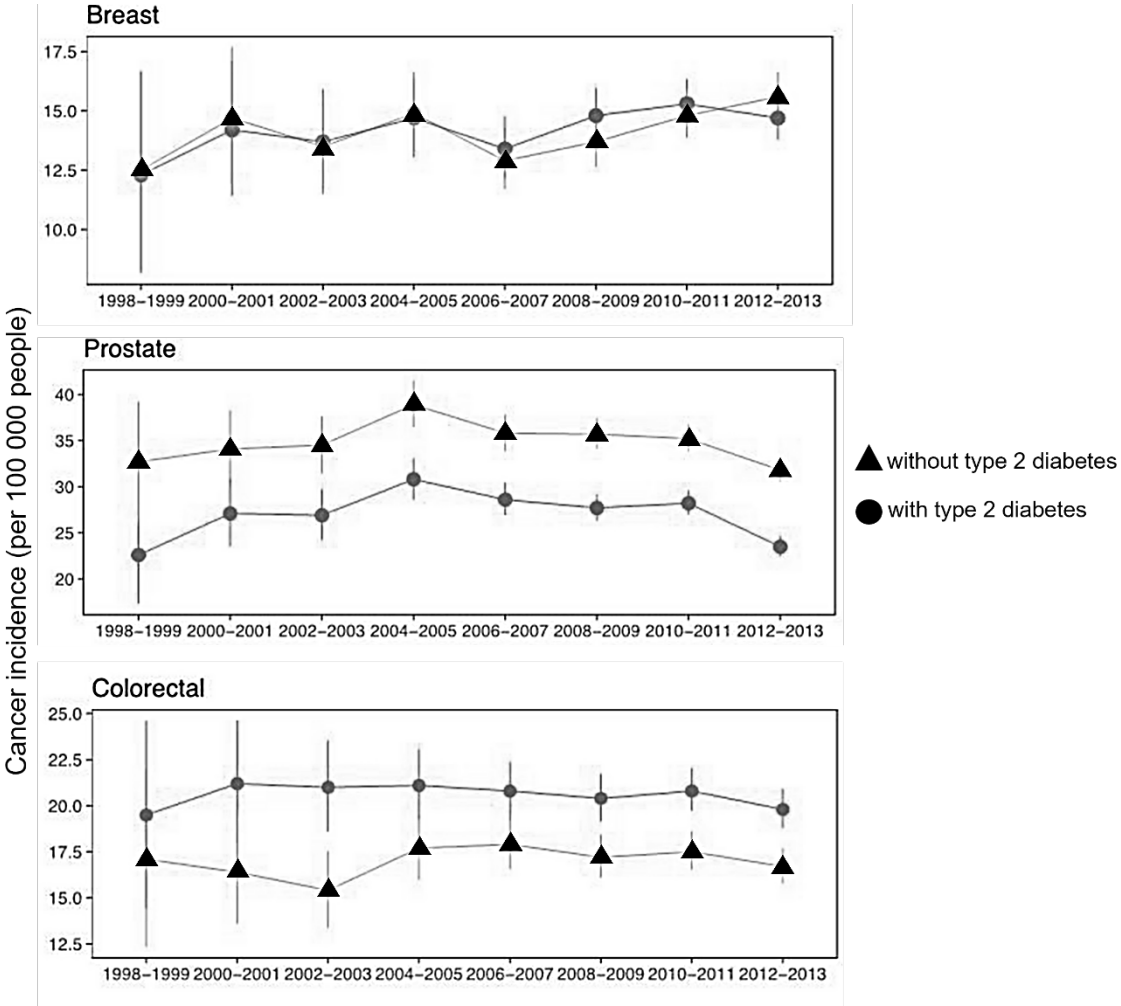

Fig. 1.1

(b) "People with type 2 diabetes are at higher risk of cancer."

Using Fig. 1.1, discuss if the above statement is valid.

[6]

(c) Age has been identified as a risk factor common to both cancer and type 2 diabetes. In economically developed countries, 78% of all newly diagnosed cancer cases are among individuals aged 55 years and older.

In the US, it is reported that the prevalence of type 2 diabetes among those 60 years or older is almost ten-fold the prevalence of type 2 diabetes among those between 20 to 39 years of age.

(i) Explain why the risk of cancer increases with age.

[2]

(ii) Suggest one reason why the risk of type 2 diabetes increases with age.

[1]

(d) Apart from age, diet has also been identified as a risk factor for type 2 diabetes. Many research studies have attempted to investigate the relationships between:

- the percentage of energy intake in the diet that comes from saturated fatty acids and the risk of developing type 2 diabetes;
- the concentration of low-density lipoprotein (LDL) in the blood and the risk of developing type 2 diabetes.

Fig. 1.2 shows three proposed causal links between diet and type 2 diabetes as arrows **P**, **Q** and **R**. For example, the causal link represented by arrow **P** is the idea that an increase in saturated fatty acids in the diet **causes** an increase in the concentration of LDL in the blood.

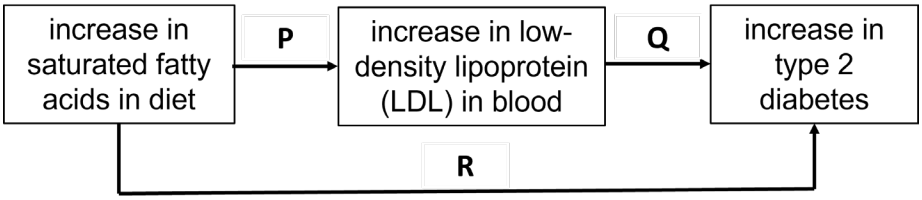

Fig. 1.2

The findings from some of these research studies are shown in Fig. 1.3, Fig. 1.4, Fig. 1.5 and Fig. 1.6.

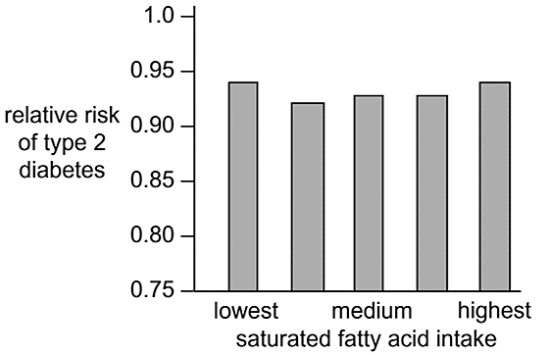

Fig. 1.3

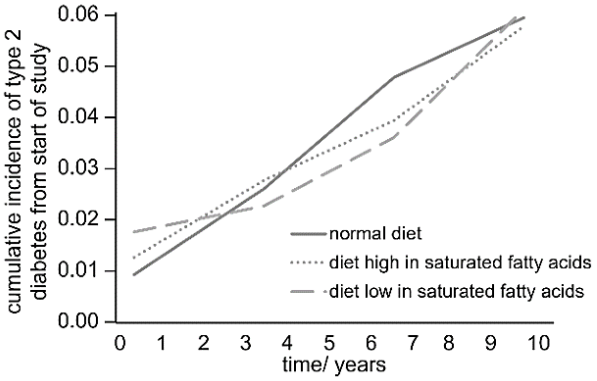

Fig. 1.4

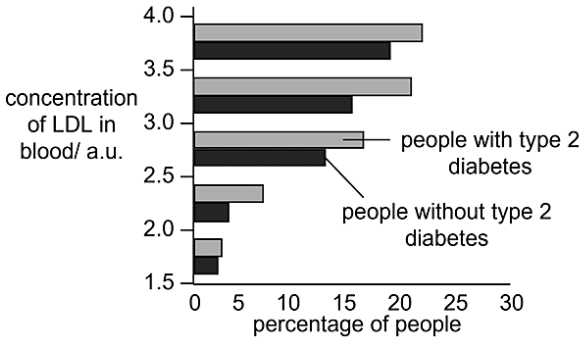

Fig. 1.5

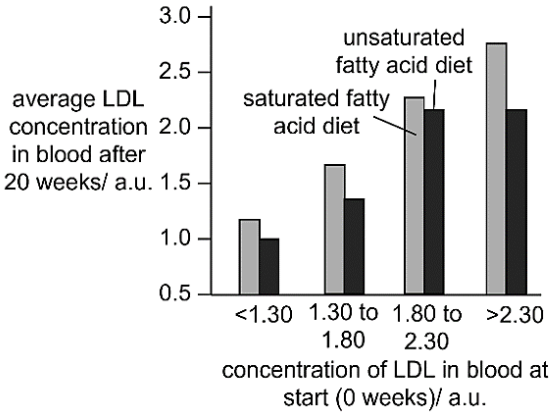

Fig. 1.6

(i) Complete Table 1.2 to show for each set of results:

- which of the causal links of the proposed in Fig. 1.2 were investigated (write **P**, **Q** or **R**)
- whether the results support the casual link shown by this arrow (writes yes or no).

Table 1.2

results	casual link investigated	do the results support the causal link?
Fig. 1.3		
Fig. 1.4		
Fig. 1.5		
Fig. 1.6		

[4]

(ii) Distinguish between the structures of a triglyceride and a fatty acid.

[2]

(iii) Low-density lipoprotein (LDL) is commonly known as “bad cholesterol”, while high-density lipoprotein (HDL) is commonly known as “good cholesterol”.

State **two** roles of cholesterol in cells.

[2]

(e) In considering the possible biological links between diabetes and cancer risk, the role of insulin receptors in mediating cellular responses to elevated blood glucose levels (hyperglycaemia) is of interest.

Most cancer cells exhibit an increased expression of insulin-like growth factor (IGF) receptors.

Fig. 1.7 shows a signal transduction pathway triggered by insulin binding to an IGF receptor on the cell surface membrane. PI3K, Akt and mTOR are protein kinases while NF-κβ is a transcription factor.

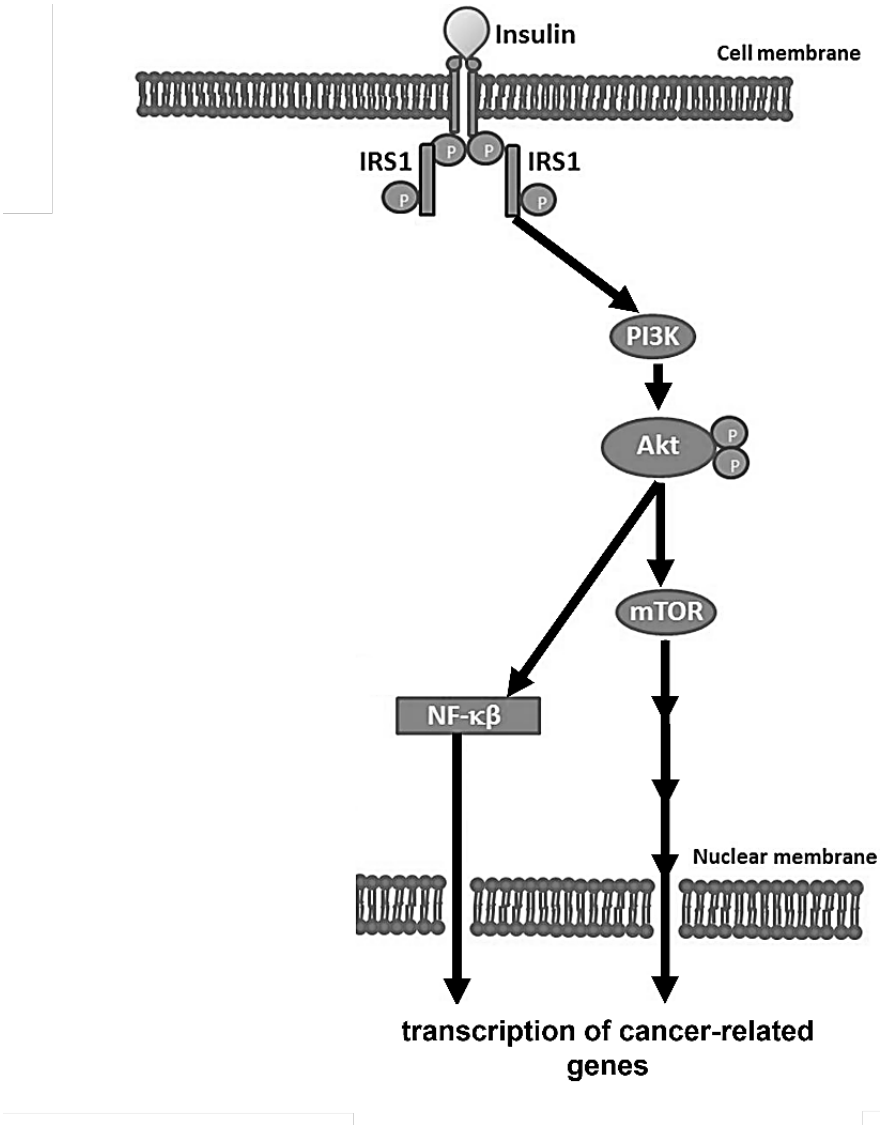

Fig. 1.7

(i) Explain why insulin needs to bind to a cell surface receptor in order to trigger downstream cellular responses.

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[2]

(ii) With reference to Fig. 1.7 and your knowledge of insulin receptors, describe how hyperglycaemia may lead to the synthesis of proteins involved in tissue invasion and metastasis.

[5]

[Total: 30]

2 In the detection of sickle-cell anaemia, part of the β-globin gene is first amplified using Polymerase Chain Reaction (PCR), with the help of *Taq* polymerase and specially designed primers.

Fig. 2.1 shows the specific location of target sequence within the DNA.

Fig. 2.1

(a) **(i)** With reference to Fig. 2.1, state the pair of 15-nucleotide long primers which can be used in the amplification of the target sequence.

.....

..... [2]

(ii) Explain one advantage and one limitation of using *Taq* polymerase instead of the DNA polymerase from *Escherichia coli* originally used in PCR.

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.....

..... [2]

In the restriction digestion step, the restriction enzyme, *Mst*II, is used to cut the amplified DNA sequence into fragments to distinguish between the normal β-globin allele (HbA) and the mutant allele (HbS).

Fig. 2.2 shows the two alleles and their respective restriction sites for *Mst*II.

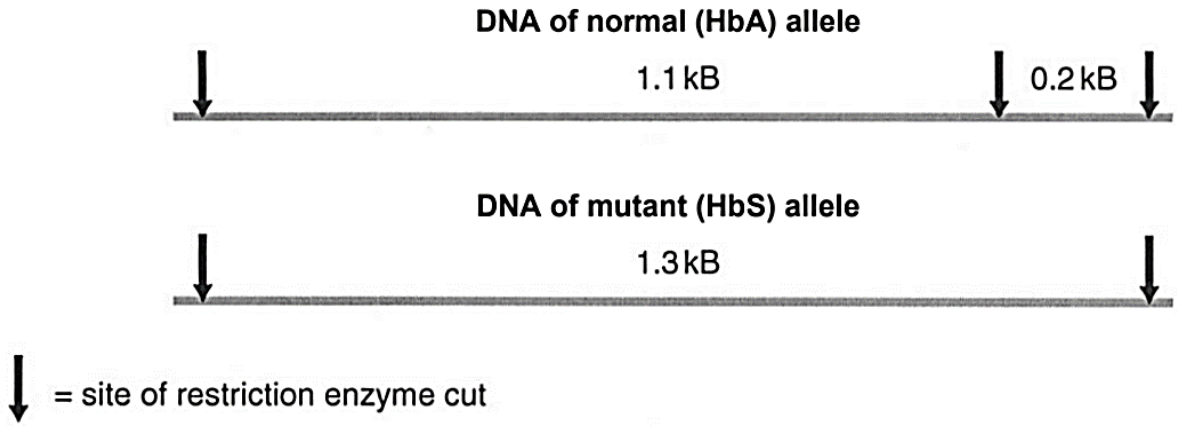

Fig. 2.2

(b) **(i)** Explain how a single base substitution resulted in the removal of one restriction site in the HbS allele.

[2]

(ii) In some laboratories, another method is employed where whole genomic DNA instead of PCR fragments is used in the restriction digest. This results in smears instead of distinct bands on the gel after gel electrophoresis is completed.

Outline the steps on how the resultant gel could still be used in detecting the disease-causing allele.

[4]

[Total: 10]

3 The *araBAD* operon, which is found in *Escherichia coli*, contains three structural genes: *araB*, *araA* and *araD* (collectively known as *araBAD*) that code for three metabolic enzymes required for the metabolism of the carbohydrate arabinose.

AraC is a regulatory protein which can act as a repressor or activator of the *araBAD* operon, depending on whether arabinose is bound to it.

Fig 3.1 shows the regulation of the *araBAD* operon.

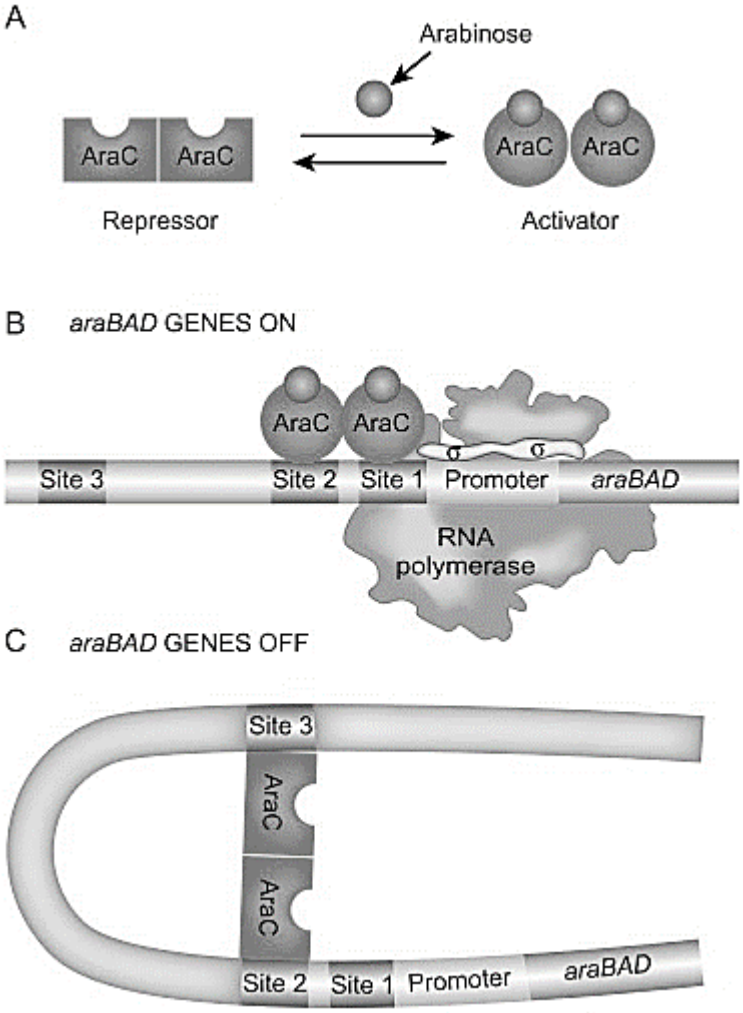

Fig. 3.1

(a) Using the information provided and your own knowledge on operons, explain whether the *araBAD* operon is an inducible or a repressible operon.

[3]

(b) Explain how a single mRNA produced from transcription of *araBAD* structural genes can be translated into three separate proteins.

[4]

(c) *AraC* gene has a gene mutation which changes the conformation of arabinose binding site.

Explain how this gene mutation affects the bacterial cell's ability to utilise arabinose.

[3]

[Total: 10]

Section B

Answer **ONE** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.
Your answers should be illustrated by large, clearly labelled diagrams, were appropriate.
Your answers must be in continuous prose, where appropriate.
You answers must be set out in parts **(a)**, **(b)**, etc., as indicated in the question.

4 **(a)** Nucleic acid is an important class of biomolecules found in all cells. [15]

Outline the roles of nucleic acids in the synthesis of proteins in eukaryotic cells.

(a) The prokaryotic genome is preserved from parent to daughter cell through vertical gene transfer and is varied from cell to cell through the processes of horizontal gene transfer.

Describe the processes by which the prokaryotic genome is preserved yet varied and justify why they are critical in giving rise to an abundance of prokaryotic cells on Earth. [10]

[Total: 25]

5 **(a)** Outline how different substances are taken up by cells. [15]

(b) Discuss the view that all life forms depend on phosphate. [10]

[Total: 25]

Question _____