

NAME: _____ CLASS: _____ INDEX: _____



CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
Higher 2

BIOLOGY

Paper 3 Long Structured and Free-Response Questions

9744/03

16 September 2025
2 Hours

Candidates answer on the Question Paper.

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your **name (as per NRIC)**, **class**, and **index number** on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]

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

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

Section A

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

Section B

Answer any **one** question in this section.

Write your answers in the writing booklet provided.

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	50
1	
2	
3	
Section B	25
4 or 5	
Total	75

Section A

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

- 1 Based on the statistics by World Health Organisation (WHO), cancer is a leading cause of death worldwide, accounting for nearly 10 million deaths in 2020, or nearly one in six deaths.

Many causative factors, including chemical carcinogens may increase the chances of cancerous growth.

- (a) Name one chemical carcinogen.

..... [1]

Studies showed that individuals inheriting *BRCA 1* gene that underwent loss-of-function mutation have an increased risk of developing breast and ovarian cancers.

- (b) Based on the information above, identify the type of gene *BRCA 1* belongs to and justify your answer.

.....

 [2]

Mutations in another gene, *BRCA 2*, was shown to increase the risk of developing breast and ovarian cancers. Fig. 1.1 shows the percentage risk of developing these cancers in general population, individuals with *BRCA 1* mutations, and individuals with *BRCA 2* mutations.

Percentage / %

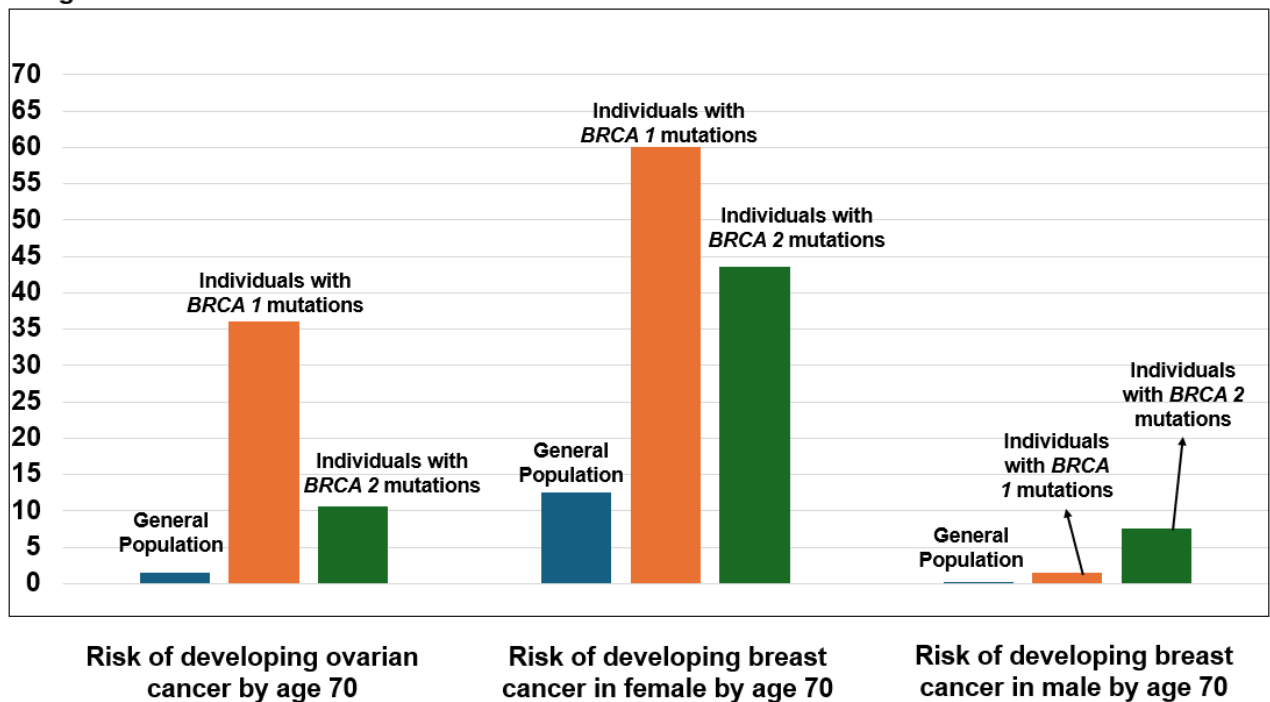


Fig. 1.1

(c) With reference to Fig. 1.1,

(i) describe the effect of *BRCA 1* mutations on the risk of developing ovarian cancer.

.....
 [1]

(ii) describe the effects of *BRCA 2* mutations on the risk of developing breast cancer.

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 [2]

(iii) compare the effects of *BRCA 1* mutations and *BRCA 2* mutations on the risk of developing breast cancer.

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 [3]

(iv) suggest an explanation for the differences in the effects of *BRCA 1* mutations and *BRCA 2* mutations on the risk of developing breast cancer.

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 [1]

DNA replication is an important process prior to cell division.

Base-pairs mismatch may sometimes occur during DNA replication. This base-pair mismatch can often be rectified during the elongation stage by the proofreading activity of DNA polymerase.

Fig. 1.2 briefly illustrates the mechanism of proofreading activity in eukaryotic DNA polymerase δ .

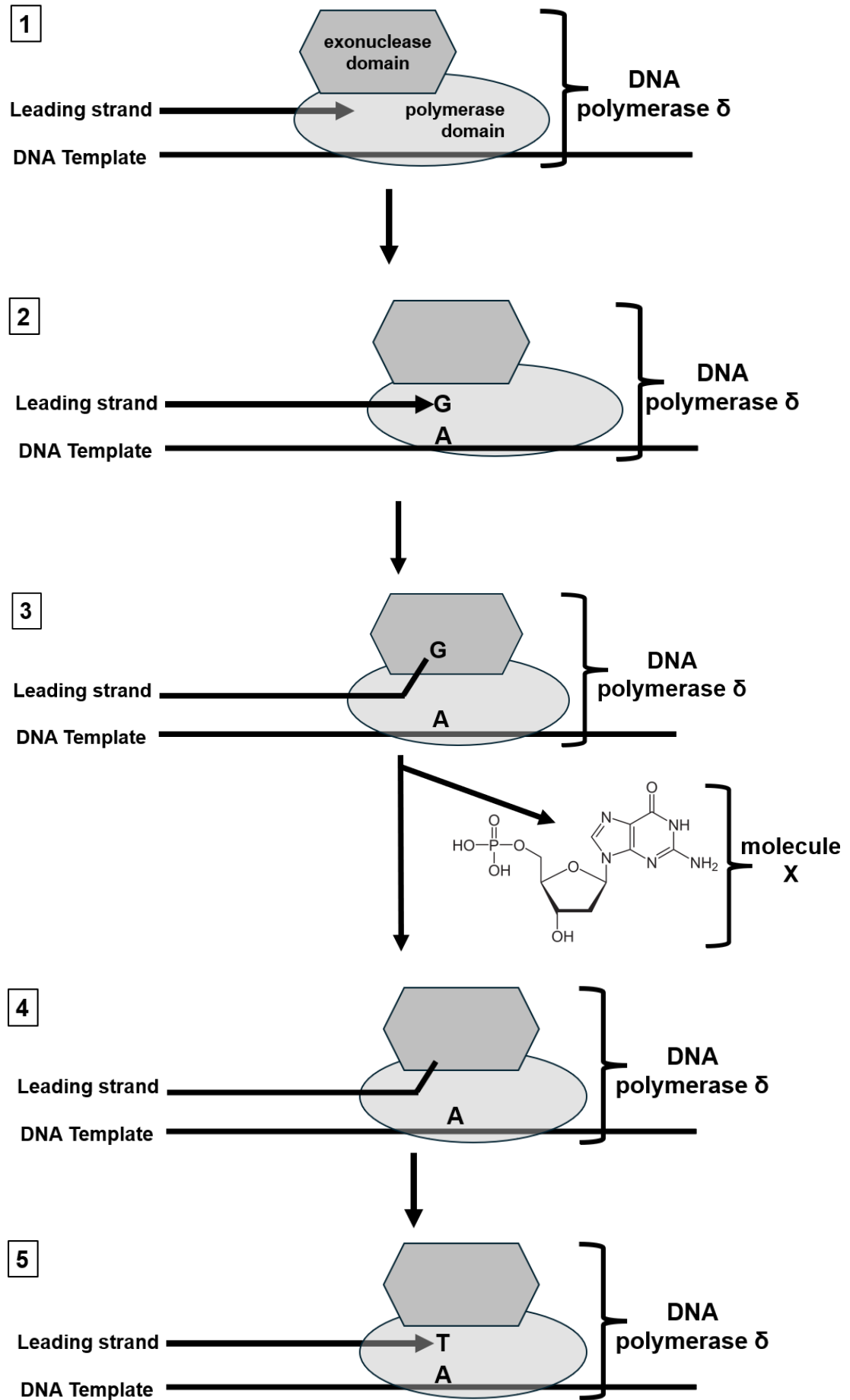


Fig. 1.2

(d) With reference to Fig. 1.2,

(i) identify molecule **X**.

..... [1]

(ii) describe the events that occurred to enable the correct base to be incorporated by DNA polymerase δ when there was a base-pair mismatch.

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 [5]

(iii) suggest the directionality of the activity the exonuclease domain on the leading strand. Justify your answer.

.....

 [2]

If the proofreading activity of DNA polymerase and other DNA repair mechanisms fail to rectify errors during DNA replication, mutations occur.

Mutation in the Kirsten rat sarcoma (*K-Ras*) proto-oncogene is commonly found in patients with colorectal cancer.

(e) Mutation in *K-Ras* gene is not passed down to the offsprings. Name this type of mutation.

..... [1]

In one of the studies, the resulting mutant K-Ras protein was purified from colorectal cancer cells and crystallography was performed to determine the structure of the protein.

Fig. 1.3 shows the structure of the mutant K-Ras protein in the presence and absence of growth factors.

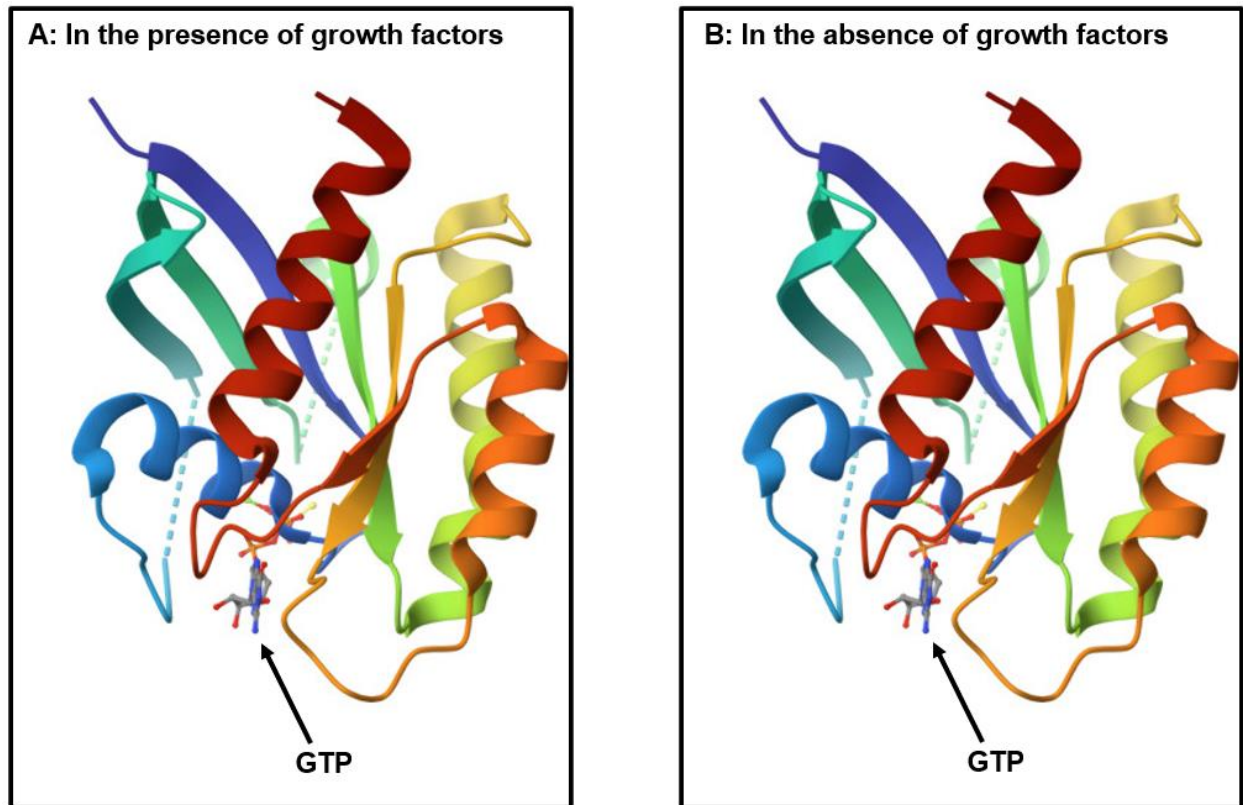


Fig. 1.3

- (f) With reference Fig. 1.3, identify the level of protein structure of K-Ras protein.

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..... [3]

- (g) Based on the information provided above and Fig. 1.3, suggest how mutation in *K-Ras* gene contributes to the development of colorectal cancer.

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..... [4]

Cancer cells and stem cells are similar in many ways. One of the similarities is their abilities to maintain the length of telomere despite multiple rounds of successive DNA replication.

- (h) Apart from their ability to maintain the length of telomere, compare the features of cancer cells and embryonic stem cells.

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..... [2]

- (i) *“Telomerase prevents end-of-replication problem in both cancer and stem cells”.*

Comment on the accuracy of the statement.

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..... [3]

[Total: 31]

- 2** Polymerase Chain Reaction (PCR) possesses the potential to generate billions of copies of target DNA from a single copy.

One of the requirements of this method is having information on at least partial sequences of the target DNA, which is needed to design primers that hybridise specifically to the target sequences.

DNA primers are often 18-30 bases in length.

- (a) Suggest why the length of the primers cannot be too short or too long.

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..... [2]

COVID-19 is caused by a positive-sense, single-stranded RNA virus called SARS-CoV-2.

During the COVID-19 pandemic, a modified PCR technique called Reverse Transcription quantitative Polymerase Chain Reaction (RT-qPCR) became a cornerstone for diagnosing the infection.

In RT-qPCR, the genetic material of SARS-CoV-2 RNA is first converted into double stranded DNA.

(b) Describe how double stranded DNA is obtained from SARS-CoV-2 RNA.

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..... [4]

After conversion into double stranded DNA, the amplification process is monitored with the aid of using a DNA probe attached to a fluorescent dye.

Figure 2.1. illustrates how fluorescence is released during the amplification in RT-qPCR.

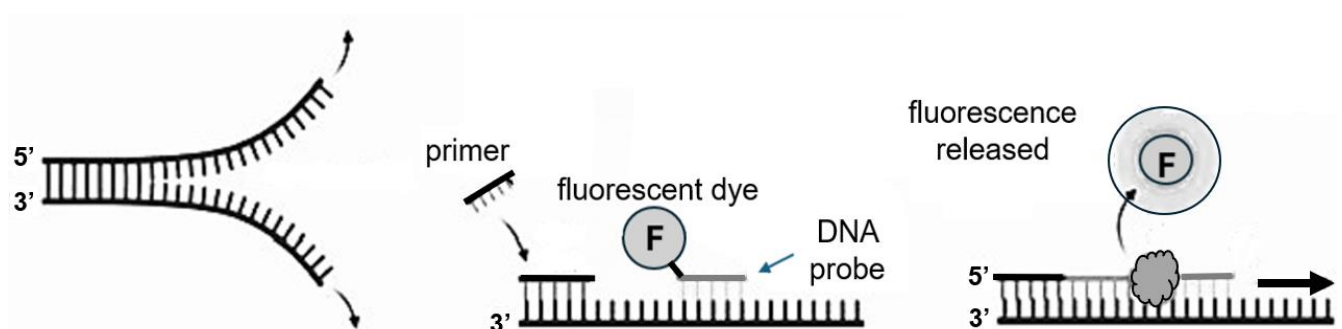


Fig. 2.1

(c) With reference to Fig. 2.1, explain how fluorescence is released during RT-qPCR.

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..... [3]

During the amplification process, the fluorescence intensity is quantified real time using a spectrophotometer.

Fig. 2.2 shows the graph of fluorescence against the number of cycles of amplification.

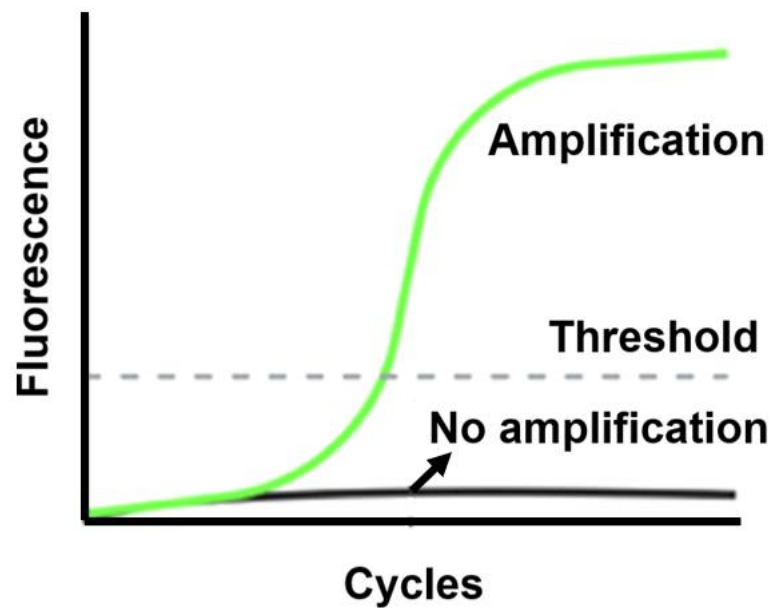


Fig. 2.2

The number of PCR cycles for fluorescence intensity to reach or exceed threshold depends on the concentration of SARS-CoV-2 in the sample.

(d) With reference to Fig. 2.2,

- (i) suggest how RT-qPCR can distinguish patients with high SARS-CoV-2 viral load from patients with low SARS-CoV-2 viral load.

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 [1]

- (ii) suggest why there is low fluorescence intensity despite no amplification.

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 [1]

[Total: 11]

- 3 North America is home to diverse migratory bird species that travel long distances between their breeding grounds in the north and wintering grounds in the south. One such migratory bird species is the American robin. During the winter season, the robins migrate from the northern region of Canada to the southern region to seek for their food source – caterpillars.

Over the years, climate change has impacted the population of American robins, their migration pattern, and possibly their survival.

Fig. 3.1 below shows the average global temperature over the years.

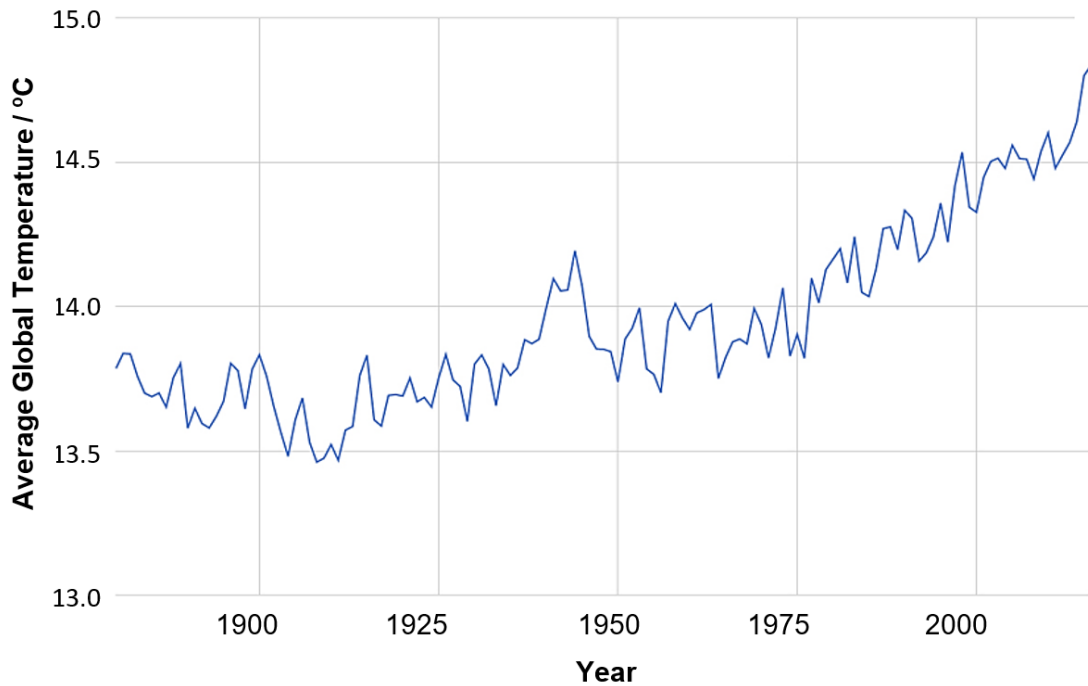


Fig. 3.1

Fig. 3.2 shows the migration period of the robins from north Canada to south Canada in 1950 and 2000.

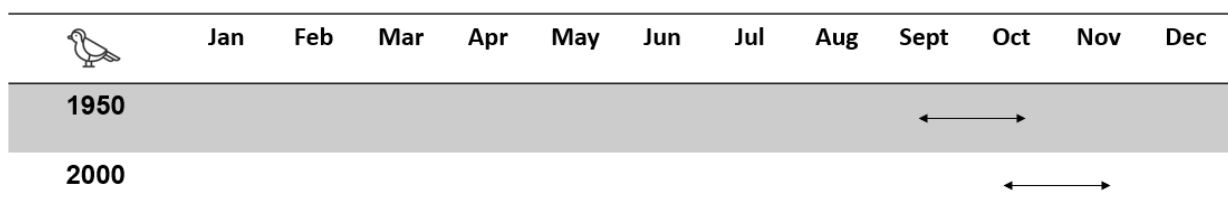


Fig. 3.2

Fig. 3.3 shows the period where there is great abundance of caterpillars in south Canada in 1950 and 2000.

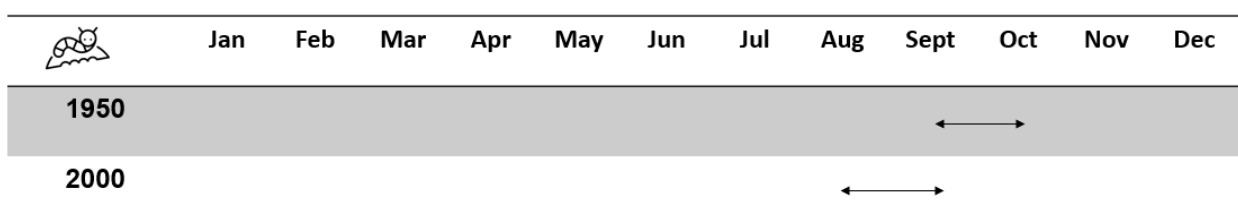


Fig 3.3

Climate change has been said to affect the migratory phenology of the American robins.

- (a) With reference to Fig. 3.1 and 3.2, describe and explain how climate change has caused the change in the migration pattern.

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..... [3]

- (b) Explain why the caterpillars are found in abundance earlier as shown in Fig. 3.3.

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..... [2]

- (c) Discuss how the changes shown in Fig. 3.2 and Fig. 3.3 can impact the American robins.

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..... [3]

[Total: 8]

Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

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

Your answer must be in continuous prose, where appropriate.

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

- 4 (a)** Describe how transformation, transduction and conjugation give rise to variation in prokaryotic genomes and explain why genetic variation is important in bacteria. [15]

- (b)** Microorganisms such as *Escherichia coli* (*E. coli*) colonise the intestine and obtain nutrients from their surroundings.

Describe how *E. coli* responds to the presence of lactose and absence of glucose in the intestine and explain how a mutation in the regulatory sequence of the *lac* operon may affect how *E. coli* responds to changes in lactose supply. [10]

[Total: 25]

- 5 (a)** Explain the role of the different coenzymes in respiration. [15]

- (b)** Cyanide is a rapidly acting and lethal toxin that disrupts cellular respiration, leading to severe oxygen deprivation at the cellular level. It irreversibly binds to the iron found in haemoglobin and the enzymes in the electron transport chain.

Explain the effect of cyanide on respiration and suggest possible treatments. [10]

[Total: 25]

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