EUNOIA JUNIOR COLLEGE
JC1 Promotional Examination 2022
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME								
CIVICS GROUP	**2**	**2**	**-**			REGISTRATION NUMBER		

H2 Biology **9744 / 02**

04 October 2022

2 hours

Additional Materials: 12-page Answer Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.

Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.

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

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

Section B
Answer **all** questions in the 12-page Answer Booklet.

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.

At the end of the examination, submit the Question Booklet and the 12-page Answer Booklet separately.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
Section B	
6	
Total	**80**

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

Section A

Answer **all** questions in the spaces provided.

1 Fig. 1.1 shows the process of collagen synthesis in a fibroblast cell.

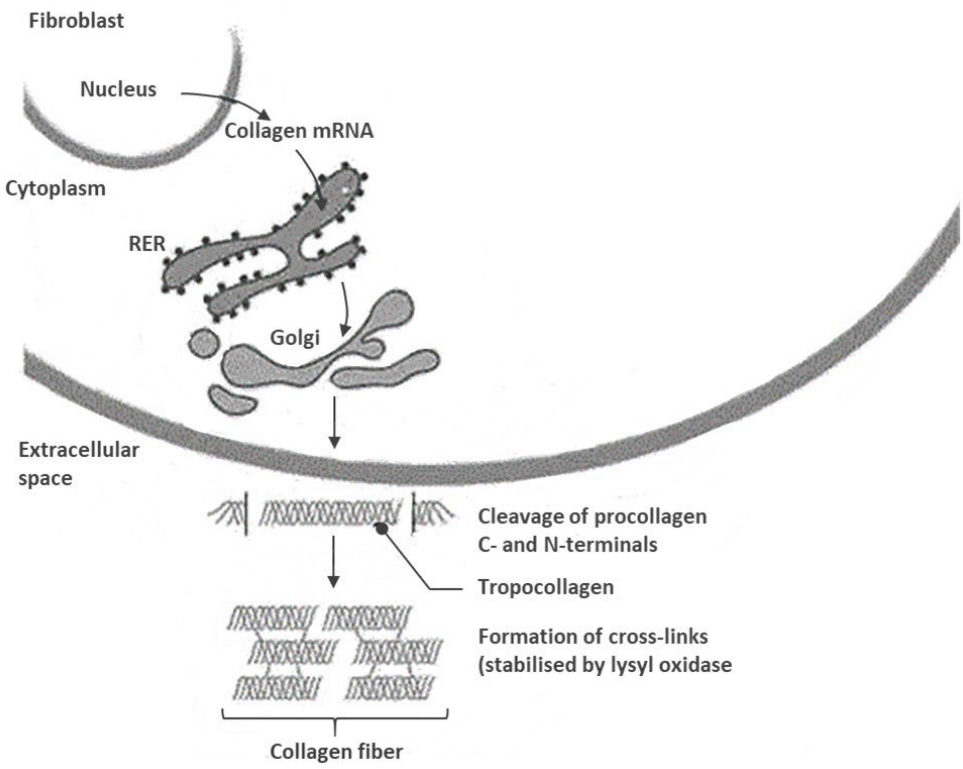

Fig. 1.1

(a) With reference to Fig. 1.1, describe how procollagen is transported out of the cell.

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..... [3]

(b) The primary structure of a collagen polypeptide has a repeating pattern of three amino acids.

Fig. 1.2 shows the two forms of this pattern.

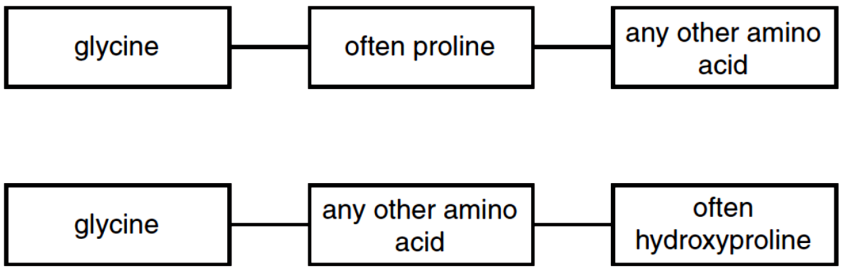

Fig. 1.2

Hydroxyproline is a proline molecule that has a hydroxyl (-OH) group added to its R-group. The hydroxyl groups are involved in hydrogen bonding in tropocollagen.

Glycine makes up approximately 30% of the total amino acid composition of collagen.

Explain how the structure of glycine plays an essential role in contributing to the high tensile strength of tropocollagen.

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..... [3]

(c) Many of the lysine amino acids in a collagen polypeptide also have a hydroxyl (-OH) group added to their R-group.

Fig. 1.3 shows hydroxylysine.

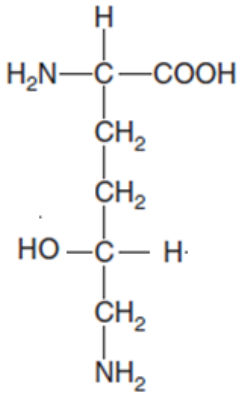

Fig. 1.3

(i) On Fig. 1.3, draw a box around the R group of hydroxylysine. [1]

The hydroxyl group of hydroxylysine is important as a possible attachment site for a β-galactose molecule. The joining of β-galactose to hydroxylysine involves the formation of a glycosidic bond.

The molecular structure of β-galactose is shown in Fig. 1.4.

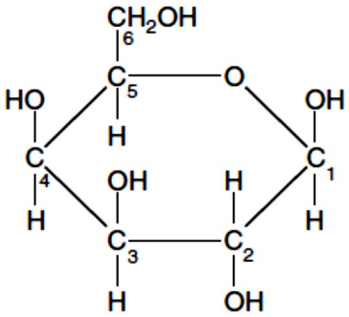

Fig. 1.4

(ii) Show how a glycosidic bond could be formed between carbon 1 of β-galactose and the R group of hydroxylysine.

[3]

[Total: 10]

2 In human retinal photoreceptor cells, the *EGFLAM* gene codes for a protein known as Pikachurin.

The production of this protein is depicted in Fig. 2.1 below.

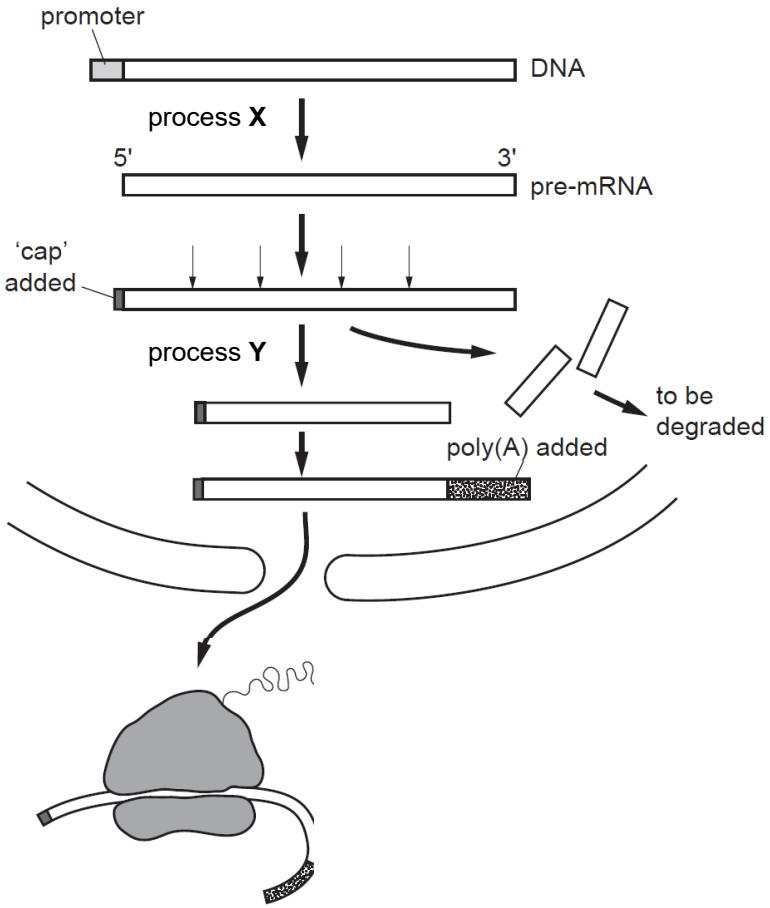

Fig. 2.1

(a) **(i)** Describe process **Y**.

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.....[3]

(ii) Contrast DNA replication with process **X**.

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Fig. 2.2 shows a section of the *EGFLAM* mRNA molecule.

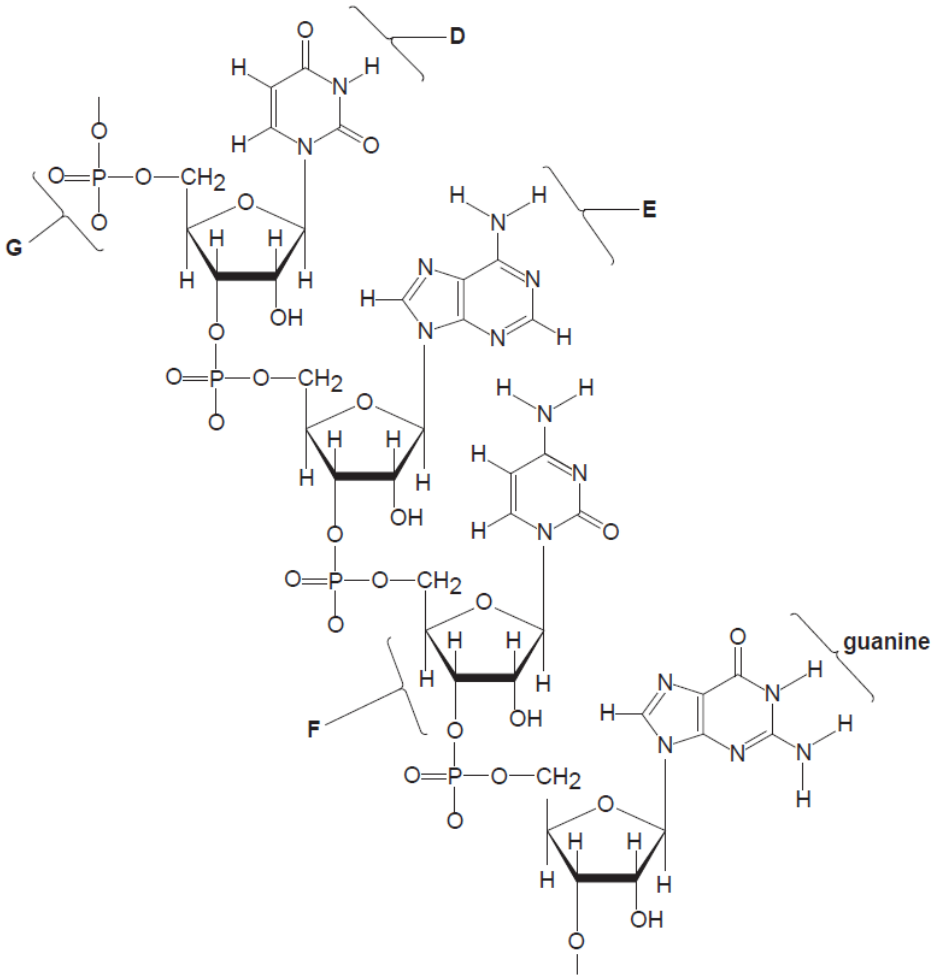

Fig. 2.2

(b) **(i)** It is known that **D** and **E** are complementary bases.

Name the parts of the mRNA molecule labelled **D**, **E**, **F**, and **G**.

D: ……..... **E**: …….....

F: ……..... **G**: ……..... [2]

(ii) Explain why the ribosomal proteins that interact with the mRNA molecule are made of mostly positively charged amino acids.

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.....[2]

It was discovered that the protein Otx2 plays a large role in regulating the formation of the sensory organs, including the eye and optic nerve. This protein is encoded by the *OTX2* gene.

Fig. 2.3 shows the changes in mRNA levels of the *OTX2* and *EGFLAM* genes.

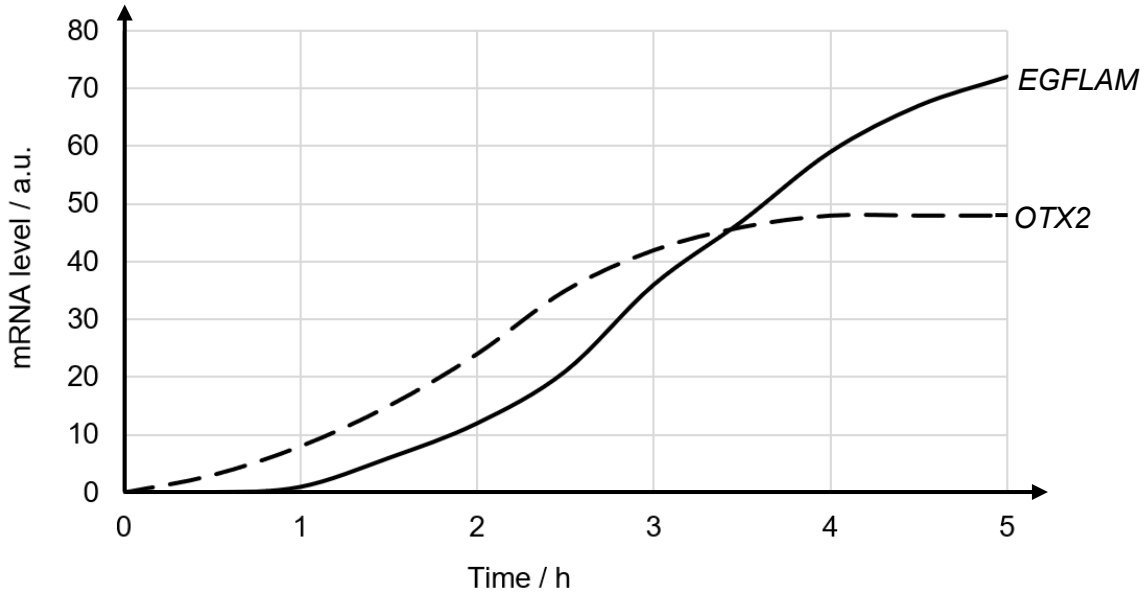

Fig. 2.3

(c) **(i)** Calculate the average rate of *OTX2* mRNA production over 5 hours.

[1]

(ii) With reference to Fig. 2.3, describe the changes in *EGFLAM* mRNA level.

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…….....

.....[2]

(iii) OTX2 protein was found to bind to a DNA sequence far away from the *EGFLAM* gene.

Explain how the Otx2 protein regulates *EGFLAM* gene expression.

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.....[3]

Upon translation of *EGFLAM* mRNA, the polypeptide produced must first be processed before it is folded into metabolically active Pikachurin protein.

Fig. 2.4 shows the production of active Pikachurin protein from a Pikachurin polypeptide.

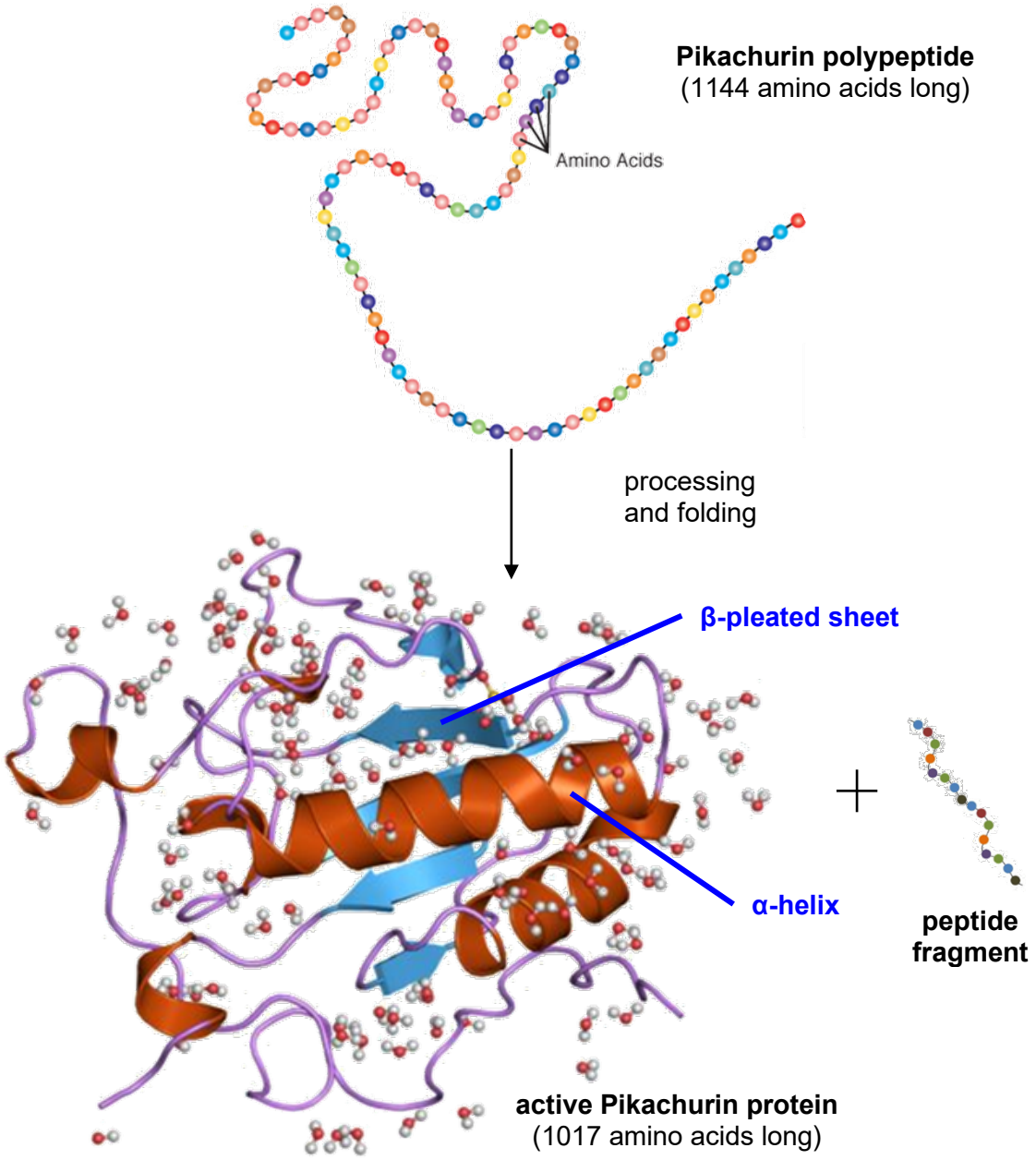

Fig. 2.4

(d) **(i)** Using separate label lines, label on Fig. 2.4 **two** types of secondary structures. [1]

(ii) Describe the processing that the Pikachurin polypeptide undergoes to form the active Pikachurin protein.

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.....[2]

[Total: 20]

3 A student investigated growth in the roots of broad bean, *Vicia faba*. The student cut sections of the root tip of this plant and viewed them with a light microscope.

Fig. 3.1 is a photomicrograph of one of the sections. The cells labelled A to C illustrate certain stages of a type of nuclear division.

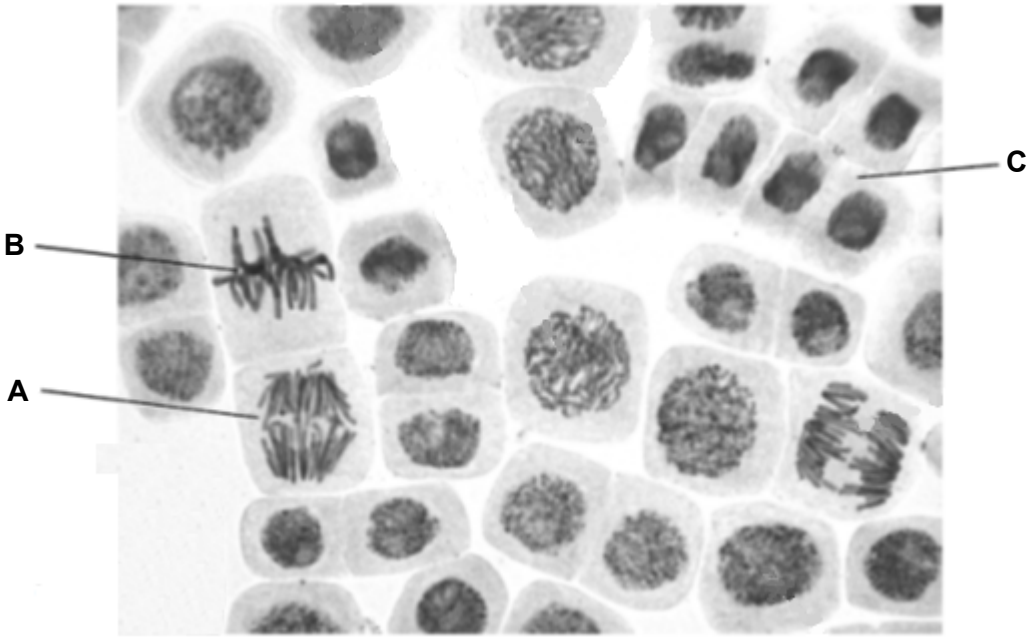

Fig. 3.1

(a) With respect to Fig. 3.1, identify the

(i) type of nuclear division,

.....[1]

(ii) following stages of the nuclear division in cells B and C.

Cell B .....

Cell C .....

[1]

(b) The diploid number of the broad bean plant is 12.

(i) State a difference between chromosome 8 in cell A and cell B.

…….....

.....[1]

(ii) Explain if cell A has the same number of chromosomes as cell B.

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.....[3]

The chemical, vincristine, is known to affect the polymerisation of tubulin to form microtubules.

The effect of vincristine is illustrated in Fig. 3.2.

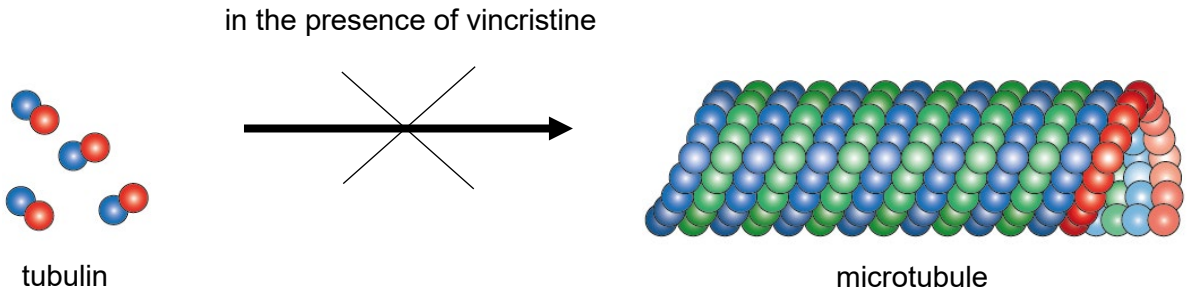

Fig. 3.2

(c) The student decided to investigate the effect of vincristine on dividing root tip cells of the broad bean.

Explain the effect of vincristine on the genetic material found in the daughter cells.

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…… [4]

[Total: 10]

4 The *ara* operon is an inducible operon involved in the breakdown of a pentose sugar, arabinose. Fig. 4.1 shows the organisation of the *ara* operon in a bacterium.

The *ara* operon encodes three structural genes (*araB*, *araA* and *araD*) and is regulated by the regulatory gene *araC*.

The arrows in Fig 4.1 represent the directions of transcription of the respective genes.

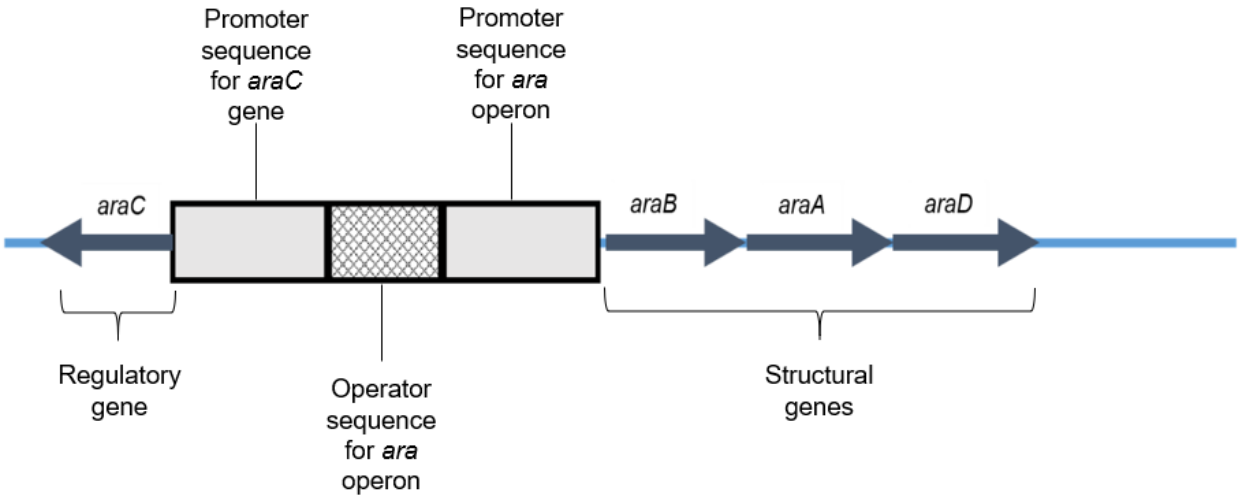

Fig. 4.1

(a) With reference to Fig. 4.1, explain what is meant by the term operon and its significance.

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..... [3]

(b) Explain why the transcription of the structural genes (*araB*, *araA* and *araD*) proceeds in a different direction from the regulatory gene (*araC*). [2]

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..... [2]

(c) State another operon which is inducible in nature.

..... [1]

(d) X-gal and IPTG are chemical molecules. These molecules are commonly used to study the activity of the enzyme β-galactosidase which is synthesised by the *lac* operon in *Escherichia coli*.

X-gal is a lactose analog that turns blue when metabolised by β-galactosidase, but it does not induce the *lac* operon.

IPTG is an inducer of the *lac* operon but is not metabolised by β-galactosidase.

Based on your knowledge on the *lac* operon and the given information,

(i) place a tick in the box beside the molecule(s) that you would expect to bind to β-galactosidase. [1]

molecule	binds to β-galactosidase (✓)
allolactose	
X-gal	
IPTG	

(ii) place a tick in the box beside the molecule(s) that you would expect to bind to the Lac repressor. [1]

molecules	binds to Lac repressor (✓)
allolactose	
X-gal	
IPTG	

(iii) Suggest why operons are necessary in bacteria.

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…… [2]

[Total: 10]

5 Fig 5.1 shows a lentivirus, which can bind to cells lining the airways of the lungs. The lentivirus is a form of retrovirus. The general structure of this virus is similar to that of HIV.

The lentivirus is commonly used as a vector (vehicle to transport external copies of RNA coding for specific proteins into cells).

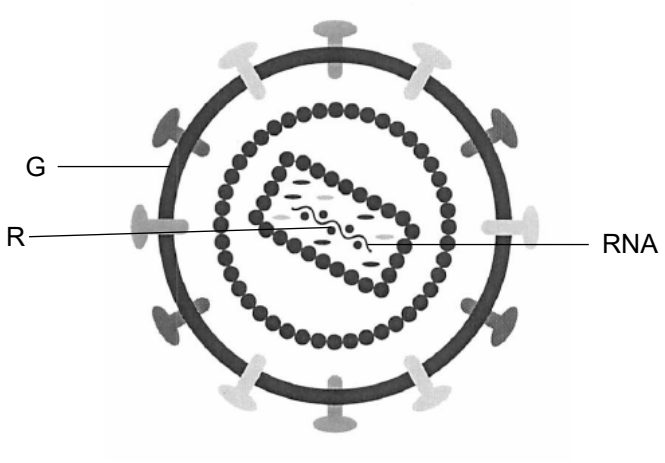

Fig. 5.1

(a) Suggest the identities of the following viral structures. [1]

G: ……..

R: ……..

(b) Explain why external copies of RNA intended to be introduced into cells cannot pass through the membrane of cells directly.

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…… [2]

(c) RNA introduced into the host cell by the lentiviral vector does not persist in the host cell for long. However, the proteins encoded by the introduced RNA can be detected in host cells even in the absence of such RNA.

Using your knowledge on retroviruses, explain how the long-term expression of these proteins can occur in host cells.

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…… [3]

(d) Lentiviruses are enveloped viruses in nature.

Describe how the virus acquires the envelope as part of its reproductive cycle in the host cell.

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…… [4]

[Total: 10]

Section B

Answer **all** questions in the 12-page Answer Booklet.

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.

6 **(a)** Distinguish between the structure of cellulose and amylopectin, and relate these to their function. [10]

(b) Other than mutation, outline the processes that result in genetic variation in nature. [10]

[Total: 20]

– END OF PAPER –

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