TEMASEK JUNIOR COLLEGE

2024 JC2 PRELIMINARY EXAMINATION

Higher 2

CANDIDATE NAME									
CENTRE NUMBER	S					INDEX NUMBER				

BIOLOGY

9744/02

Paper 2 Structured Questions

23 AUGUST 2024

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Center number, index number and name 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.
DO **NOT** WRITE IN ANY BARCODES.
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 any 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	/ 10
2	/ 9
3	/ 9
4	/ 13
5	/ 8
6	
7	
8	
9	
10	

This document consists of **27** printed pages and **1** blank page.

Answer **all** questions.

1 (a) Fig. 1.1 is a diagram of a section through a mitochondrion.

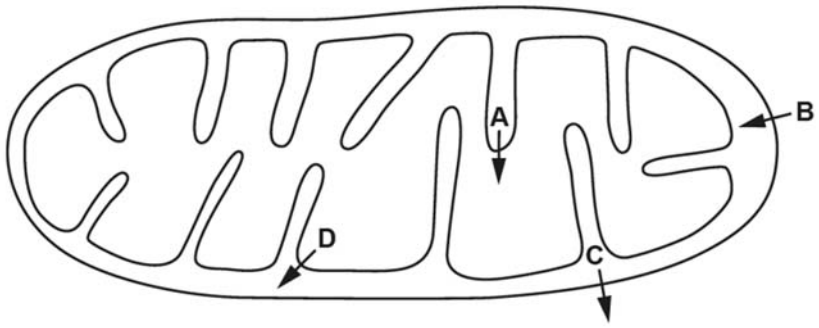

Fig. 1.1

(i) On Fig 1.1, use label lines and letters to label the positions where the following reactions take place:

X - Link reaction
Y - Krebs cycle
Z - Oxidative phosphorylation [3]

(ii) The four arrows, **A**, **B**, **C** and **D**, show the movement of molecules and ions.

Use the letters to identify **all** the arrows (one or more) that show:

Active transport of protons .....

Diffusion of carbon dioxide ……..... [2]

(b) Compare the process of oxidative phosphorylation with photophosphorylation.

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…… [2]

(c) Apart from channel proteins that allow transport of ions, plant and animals cells also have channel proteins such as aquaporins which permits the movement of water across membranes.

Explain why aquaporins are necessary.

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…… [3]

[Total: 10]

2 Fig. 2.1 shows the primary structure of a section of a polypeptide chain of collagen.

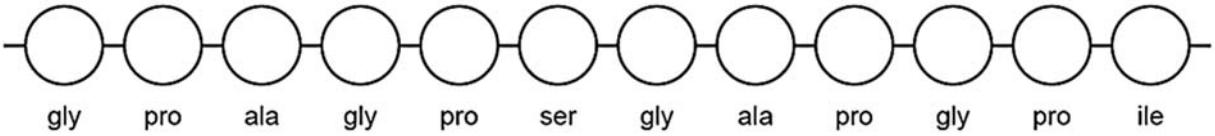

Fig. 2.1

(a) Explain how the primary structure shown in Fig. 2.1 indicates that the structure of the polypeptide is suited to be a component of a collagen molecule.

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…… [3]

Fibroblasts are cells that synthesize and secrete collagen, which forms the extracellular matrix.

Hydrolytic enzymes, known as collagenases, are secreted by some cells during wound healing.

These cells also secrete inhibitors of collagenases. The activity of the enzymes and inhibitors is regulated so that the development and maintenance of the extracellular matrix is controlled.

(b) State and explain what the outcome will be for the composition of the extracellular matrix if collagenase inhibitor activity is high.

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…… [2]

Collagenase has several important medical uses, such as in the treatment of burnt skin. Scientists investigated the effect of pH on the activity of collagenase at 37 °C.

The results of their investigation are shown in Fig. 2.2.

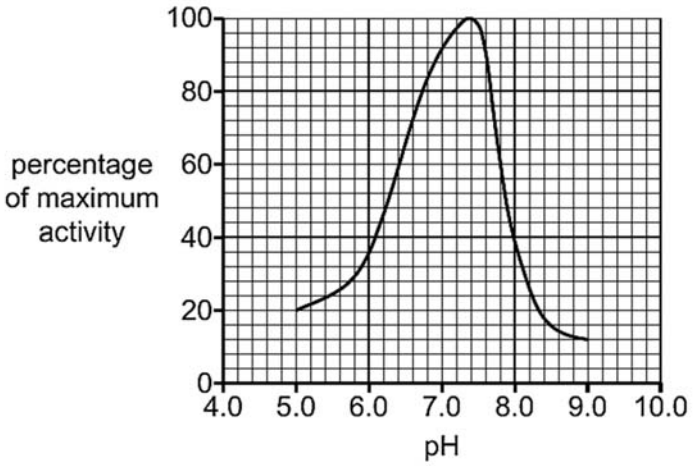

Fig. 2.2

(c) Explain why the activity of collagenase is lower at pH 8.0 than at the optimum pH.

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…… [3]

Synthetic inhibitors have been trialed as potential treatment for diseases which are caused by a lack of regulation of collagenase activity.

Fig. 2.3 shows the rate of reaction of collagenase in the absence of the synthetic inhibitor.

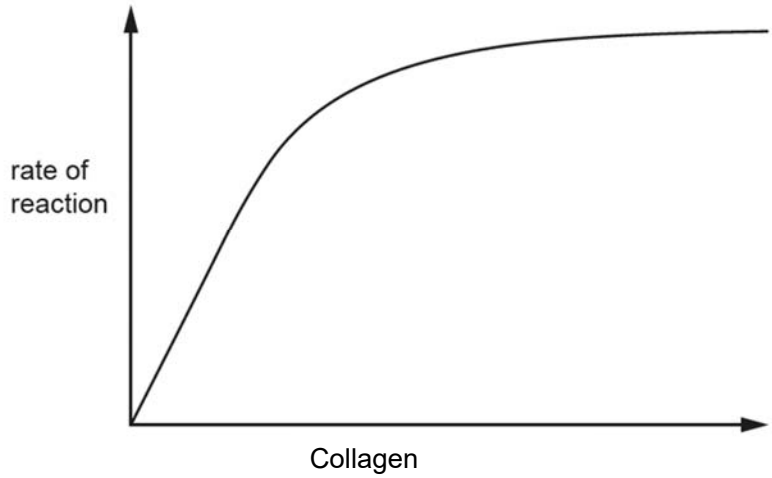

Fig. 2.3

(d) Sketch on Fig. 2.3 the curve that is expected if the synthetic inhibitor used in the trial is a non-competitive inhibitor. [1]

[Total: 9]

3 Adult stem cells in a tissue are often at different stages of the cell cycle.

(a) Fig. 3.1 shows cells at different stages of the cell cycle.

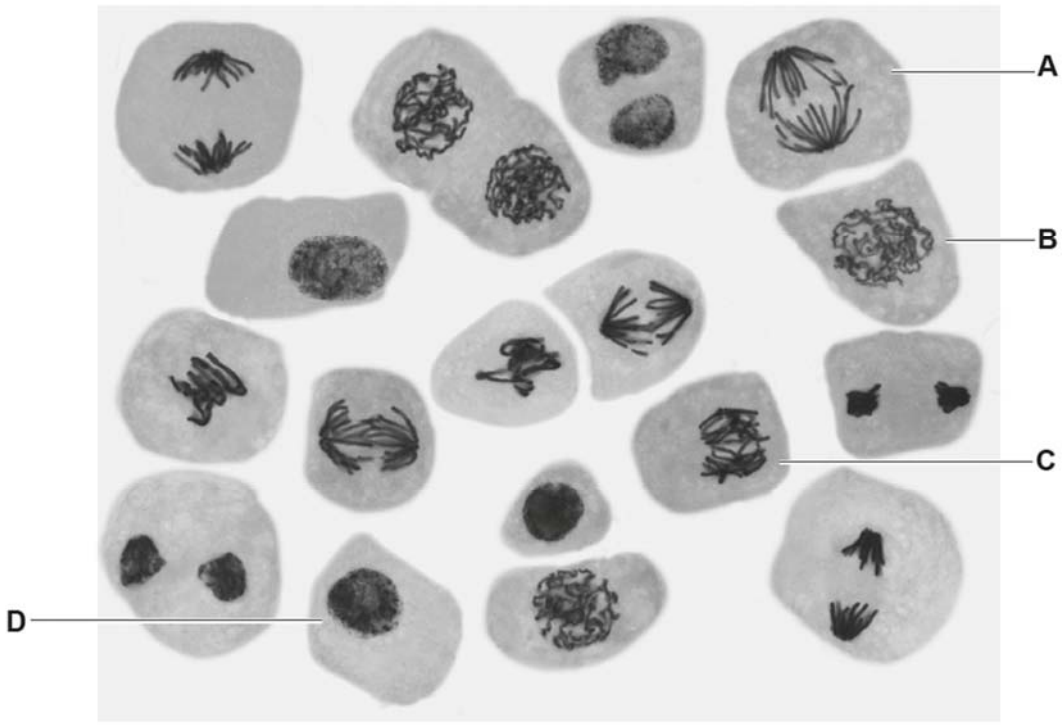

Fig. 3.1

(i) Identify the stages of mitosis occurring in the cells labelled **B** and **C** in Fig. 3.1.

B .....

C .....

[2]

(ii) Describe the behaviour of the chromosomes in the stage of mitosis shown in cell **A**.

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..... [2]

(b) Distinguish between adult stem cells and zygotic stem cells.

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…… [2]

(c) Other than stem cells, some human cells show a higher than normal activity of telomerase.

State the type of cells with higher than normal activity of telomerase and explain the role of telomerase in these cells.

Type of cell …….

Explain role of telomerase ……..……..

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……..……..…… [3]

[Total: 9]

4 Table. 4.1 shows the probabilities of being diagnosis with cancer in the various age groups. Each year, more than 1 million cases of cancer are diagnosed in the United States and more than 500 000 people die from the disease.

Table 4.1

Cancer site	Gender	Age		
		Birth to 39	**40-59**	**60-79**
Breast	Female	1 in 235	1in 25	1 in 15
Prostate	Male	<1 in 10 000	1 in 53	1 in 7
Lung	Male	1 in 3300	1 in 92	1 in 17
	Female	1 in 3180	1 in 120	1in 25
Colon	Male	1 in 1500	1 in 124	1 in 29
	Female	1 in 1900	1in 149	1 in 33

(a) Using the information in Table 4.1,

(i) state the relationship between the age of a person and the likelihood of being diagnosed with cancer;

…….. [1]

(ii) suggest a reason for your answer in **(a) (i).**

……

…… [1]

It is observed that *Ras* gene is mutated in 30% of the cancer cells.

Ras proto-oncogene codes for the Ras protein, a G protein that relays a signal from a growth factor receptor on the cell surface membrane.

Fig. 4.1 shows the cell signaling pathway involving the Ras protein. Accumulation of cyclin **D**, cyclin **E** and **E2F** proteins results in cell division.

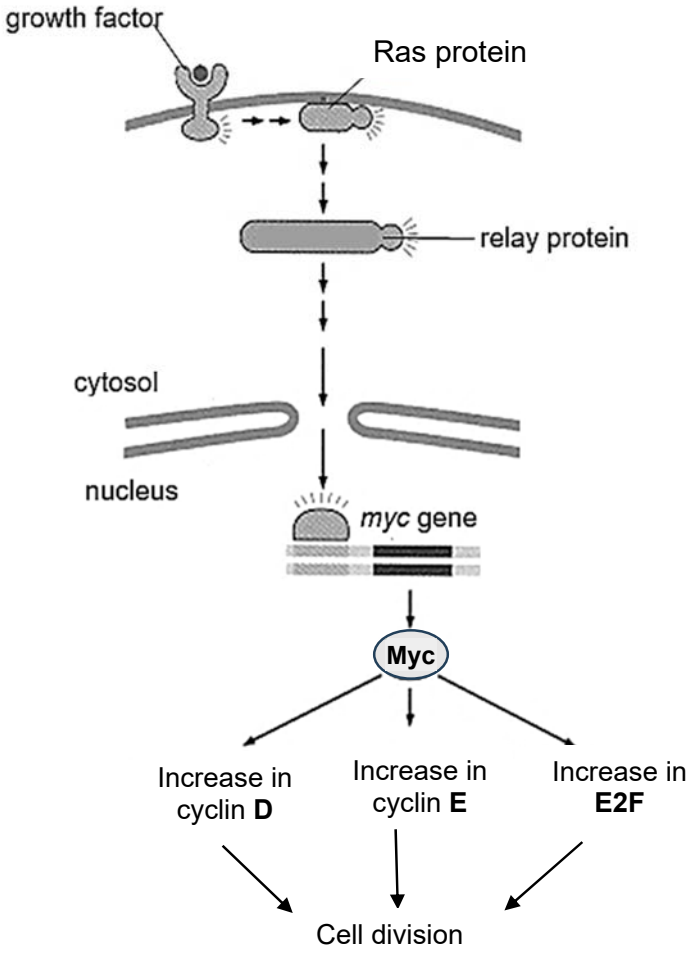

Fig. 4.1

(b) Using your knowledge and Fig. 4.1, explain how a mutation in the *Ras* gene can result in the development of cancer.

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…… [3]

(c) Suggest **one** reason why a mutated Ras protein in an eukaryotic cell will not always cause cancer directly.

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…… [1]

Ras protein signaling pathway also leads to activation of glycogen phosphorylase, which catalyzes the breakdown of glycogen. Glycogen as a polysaccharide is composed of thousands of monomers.

Oligosaccharides are carbohydrates that contain three to ten monomers in their chains.

Nystose is one example of an oligosaccharide. The structure of nystose is shown in Fig. 4.2.

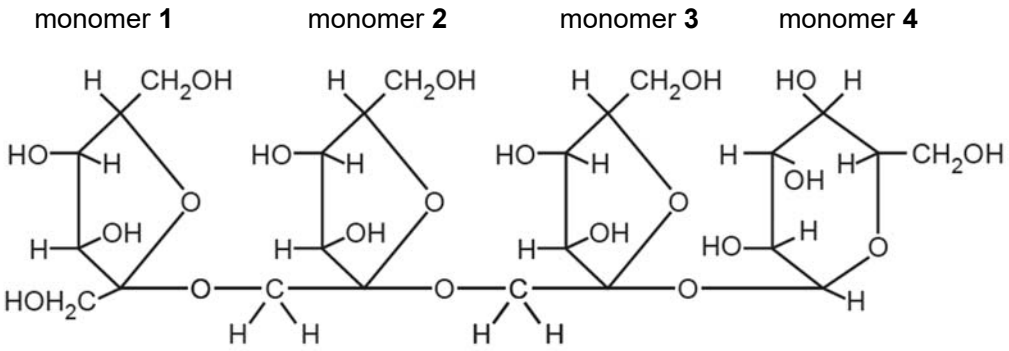

Fig. 4.2

(d) **(i)** Name the bond that is formed between monomer **3** and monomer **4**.

…… [1]

(ii) Other than the number of monomers in the molecules, describe **one** difference between the structures of nystose and glycogen.

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…… [1]

(iii) Cells use oligosaccharides to synthesise glycoproteins, which are transported to cell surface membranes as receptors.

Describe the roles of the rough endoplasmic reticulum and the Golgi body in synthesizing glycoproteins.

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…… [5]

[Total: 14]

5 Fig 5.1 shows the mTOR intracellular signalling pathway that is involved in the control of blood glucose level.

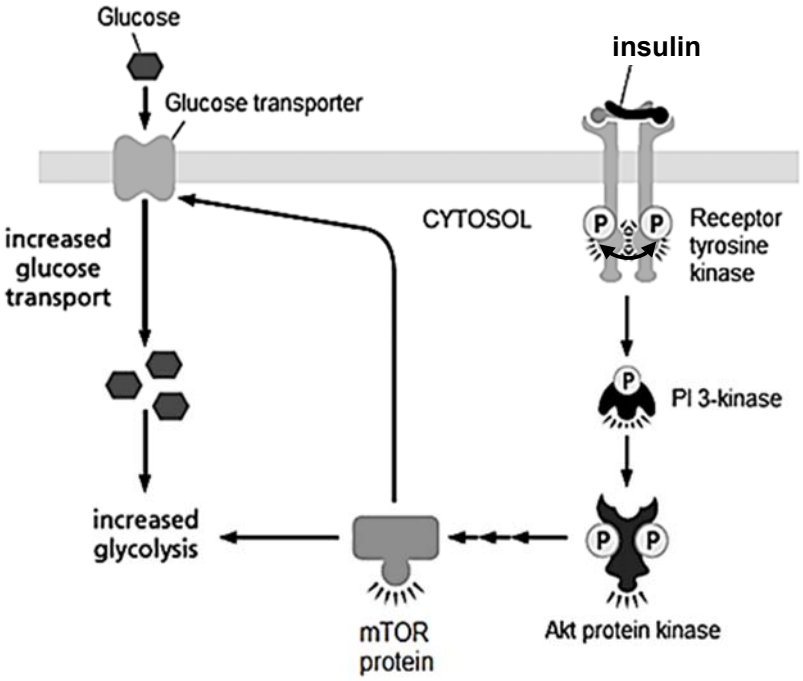

Fig. 5.1

(a) Describe how insulin leads to the activation of mTOR protein in Fig. 5.1.

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…… [3]

(b) State **two** differences between signal reception in the pathway in Fig. 5.1 and glucagon signaling pathway.

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…… [2]

(c) Describe how the receptor tyrosine kinase and glucose transporter is held in the membrane.

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…… [2]

(d) Suggest how the activated mTOR protein bring about the desired cellular responses to control blood glucose level.

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…… [1]

[Total: 8]

6 The unicellular green alga, *Chlorella*, a photosynthetic organism is studied for its many health benefits. It is produced and harvested for use as a health food supplement.

(a) To analyse the productivity of *Chlorella*, carbon dioxide concentration was altered to investigate its effects on the light-independent stage of photosynthesis.

- A cell suspension of *Chlorella* was illuminated using a bench lamp.
- The suspension was supplied with carbon dioxide at a concentration of 1% for 200 seconds.
- The concentration of carbon dioxide was then reduced to 0.03% for a further 200 seconds.
- The concentrations of RuBP and GP (PGA) were measured at regular intervals.
- Throughout the investigation the temperature of the suspension was maintained at 25 °C.

The results are shown in Fig. 6.1.

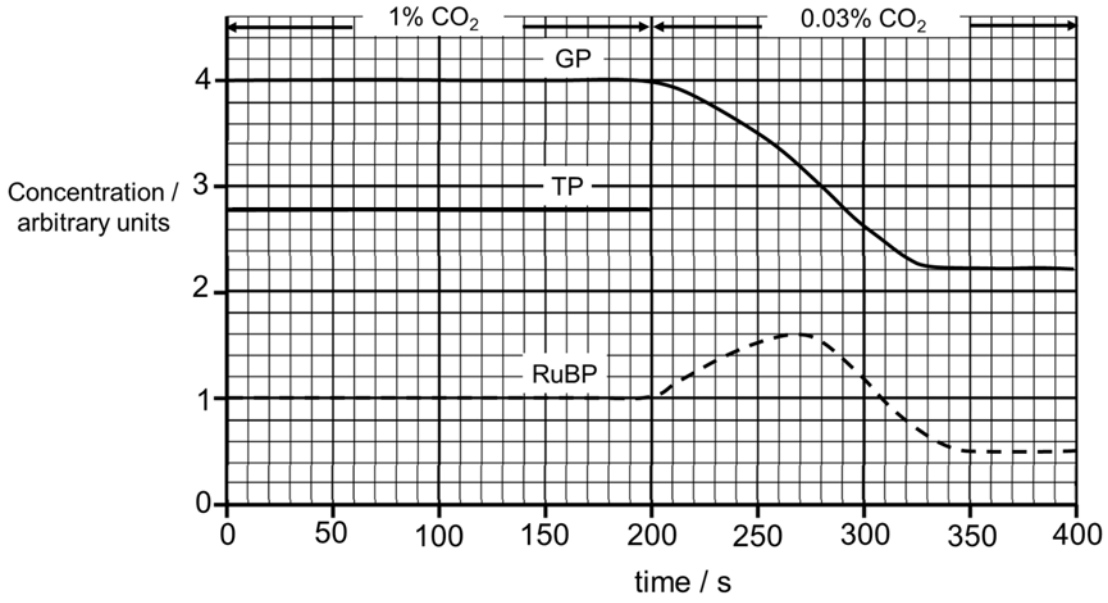

Fig. 6.1

(i) State **precisely** where RuBP and GP are located in the chloroplast.

…… [1]

(ii) Explain the change in the concentration of RuBP between 200 and 275 seconds.

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…… [2]

(iii) Calculate the rate of decrease per second in the concentration of GP between 200 and 350 seconds.

Show your working and present your answer to **two decimal places.**

…… arbitrary units per second [2]

(b) Suggest how the decrease in the concentration of GP leads to a decreased harvest for commercial suppliers of *Chlorella*.

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…… [2]

(c) In the absence of light, rubisco changes shape from an active form to an inactive form.

Briefly explain why rubisco does not need to be in an active form in the absence of light.

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…… [2]

(d) *Chlorella* can respire aerobically and anaerobically. When *Chlorella* cells switch from aerobic to anaerobic respiration, there is in a significant increase in the rate of glucose uptake and glycolysis in the *Chlorella* cells.

Suggest why the rate of glycolysis increases significantly when *Chlorella* cells switch from aerobic to anaerobic respiration.

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…… [3]

[Total: 12]

7 **(a)** During DNA replication, two new daughter strands are synthesised using the original strands as templates.

(i) State why the antiparallel nature of the DNA molecule results in one of the strands being synthesised in short fragments.

……

…… [1]

(ii) Template DNA, enzymes and ATP are necessary for DNA replication.

State **one** other component required for the process.

…… [1]

Scientists investigated the cell cycle in heart cells taken from mice 6 days before their birth and then at 4, 14 and 21 days after their birth.

The results are shown in Table 7.1.

Table 7.1

Age / days	Percentage of heart cells undergoing mitosis	Percentage of heart cells undergoing DNA replication
–6	13.9	8.5
4	8.5	2.6
14	1.6	0.2
21	0.6	0.0

Age 0 days = day of birth

(b) With reference to Table 7.1, explain the decrease in DNA replication in the heart cells after the birth of the baby.

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…… [2]

(c) The scientists determined the percentage of heart cells undergoing DNA replication by using a chemical called BrdU. These cells use BrdU instead of nucleotides containing thymine during DNA replication.

Describe how BrdU would be incorporated into new DNA during semi-conservative replication.

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…… [2]

The scientists also investigated the function of a protein called cyclin **A**, which binds to and activates one of the enzymes required at the start of DNA replication.

The percentage of cells with replicating DNA in different cell cultures was recorded as shown in Table 7.2.

Table 7.2

Cell Culture	Treatment given	Percentage of cells where DNA was replicating
C	Control cells, untreated	91
D	Antibody added that binds specifically to cyclin **A**	11
E	RNA added that prevents translation of cyclin **A**	10
F	Both RNA that prevents translation of cyclin **A** and cyclin **A** protein were added	92

(d) With reference to Table 7.2, identify and explain the treatment(s) that are suitable for targeting cancer.

Treatment ……

Explanation ……

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…… [3]

Fig. 7.1 shows a molecule of tRNA involved in the process of translation.

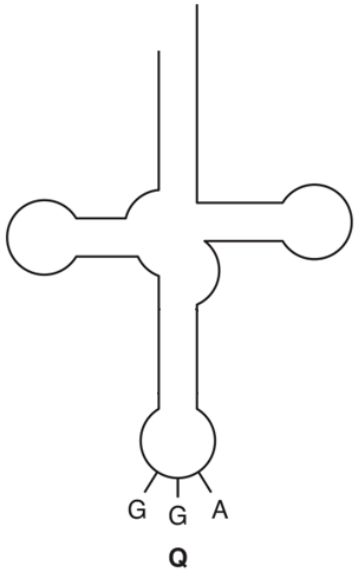

Fig. 7.1

(e) With reference to Fig. 7.1, state the name of region **Q** and explain the role of **Q** in translation.

Name ……..

Explanation ……..

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…… [3]

[Total: 12]

8 (a) Scientists have produced structures known as virosomes, which are used in certain vaccines.

Virosomes do not cause disease.

Fig. 8.1 is a diagram of a section through a virosome used in some vaccinations to protect against the virus which causes influenza.

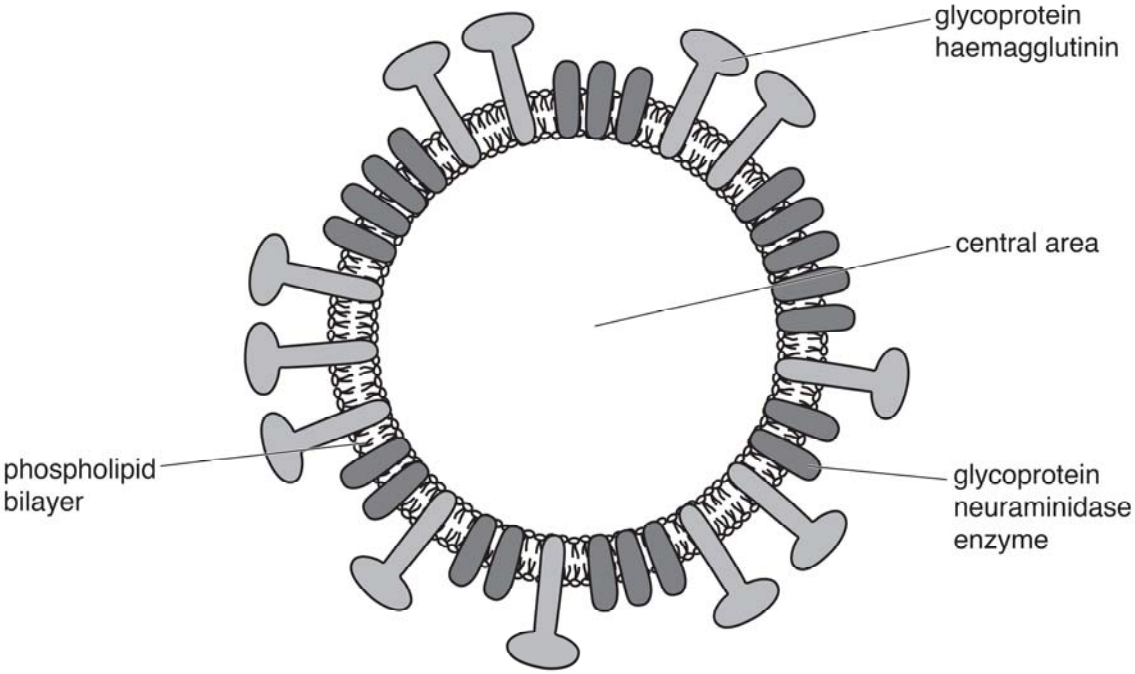

Fig. 8.1

(i) State **one** difference between the structure of a virosome and an influenza virus.

……

…… [1]

(ii) Explain how the structure of the virosome shown in Fig. 8.1 suggests that the central area of the virosome is aqueous.

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…… [2]

(b) Haemagglutinin and neuraminidase are found in the virosomes which are used in a vaccine against the influenza virus.

Briefly explain why virosomes must contain haemagglutinin.

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…… [3]

Different strains of the influenza virus have formed as a result of mutations. However, it was observed that the primary structure of the neuraminidase enzyme active site remains unchanged in each strain of the virus.

(c) Suggest why the primary structure of the active site of neuraminidase remains unchanged in each strain of the influenza virus.

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…… [2]

(d) Occasionally antigenic shift occurs in the influenza virus, resulting in human viruses responsible for influenza pandemic.

State **two** differences between antigenic shift and antigenic drift.

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…… [2]

[Total: 10]

9 The fruit fly, Drosophila melanogaster, has autosomal genes for body colour and wing shape. Pure bred wild type flies have dominant phenotypes.

Gene B/b is involved in the production of body colour:

- B = dominant allele for brown body colour
- b = recessive allele for black body colour.

Gene D/d is involved in wing shape:

- D = dominant allele for straight wing
- d = recessive allele for curved wing.

A dihybrid test cross was carried out between flies heterozygous for body colour and for wing shape and flies homozygous recessive for body colour and for wing shape.

Table 9.1 shows the number of offspring of each phenotype obtained in the test cross.

Table 9.1

phenotype	observed number	expected number
brown body colour, straight wings	2843	
brown body colour, curved wings	855	
black body colour, straight wings	842	
black body colour, curved wings	2768	

(a) Use the information in Table 9.1 to calculate the expected number of each phenotype if the two genes are on different autosomes. Write your answers in Table 9.1. [1]

(b) A chi-squared (χ^2) test was carried out to compare the observed results with the results that would be expected from a dihybrid cross involving genes on different autosomes.

The value of $\chi^2 = 20.98$

Table 7.2 shows the critical values for the χ^2 distribution.

Table 9.2

degrees of freedom	**probability, p**				
	0.10	*0.05*	*0.02*	*0.01*	*0.001*
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

(i) Explain how the value of χ^2 and Table 9.2 can be used to assess the significance of the difference between the observed results and the expected numbers in Table 9.1.

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…… [2]

(ii) Provide explanations for the test cross observed numbers shown in Table 9.1.

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…… [3]

(iii) Complete Table 9.3 by stating the genotypes of the parents involved in the test cross which gave rise to the results in Table 9.1.

Table 9.3

parent phenotypes	brown body and straight wing	X	black body and curved wing
parent genotypes			

[2]

In a separate genetic studies, it is observed that the inheritance of fruit colour in summer squash plants is controlled by two genes, **A** and **B**. Each gene has two alleles.

Fig. 9.1 shows the interaction of these two genes in controlling fruit colour in summer squash plants.

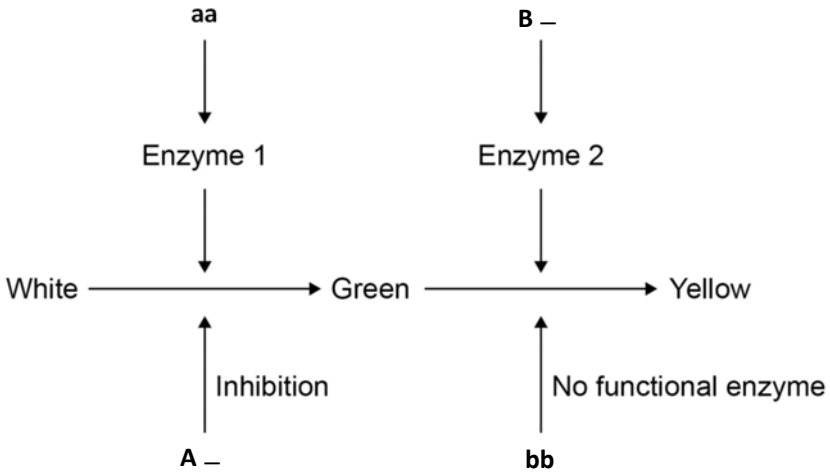

Fig. 9.1

(c) **(i)** Name the type of gene interaction shown in Fig. 9.1.

…… [1]

(ii) Genes **A** and **B** are not linked.

Complete the genetic diagram to show all the possible genotypes and the ratio of phenotypes expected in the offspring of this cross.

Genotypes of parents **AaBb** × **AaBb**

[3]

[Total: 12]

10 Table 10.1 shows the numbers of dengue cases between 2007 and 2019 in Santa Catarina, a temperate climate state in Brazil.

Table 10.1

Year	Number of dengue cases
2007	7851
2010	9618
2013	11212
2016	12630
2019	14234

(a) Calculate the rate of increase in the number of dengue cases between 2007 and 2019.

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

rate of increase = ... per year [2]

(b) Using your knowledge of the effects of climate change, explain the rise in dengue cases between 2007 to 2019.

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…… [3]

[Total: 5]

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