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NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY **9744/02**

Paper 2 Structured Questions **15 September 2025**

Candidates answer on the Question Paper.
No Additional Materials are required. **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your name and CT 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 no use staples, paper clips, highlighters, 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 your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
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11	
Total	

This document consists of **27** printed pages and **2** blank pages.

[Turn over

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

1 In the majority of cell types, ribosomes are the most common organelle. They are found in the cytoplasm of bacterial and eukaryotic cells.

(a) **(i)** List the **two** types of biomolecule that are found in ribosomes.

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[1]

(ii) State one difference between the ribosomes found in the cytoplasm of bacteria and the ribosomes found in the cytoplasm of eukaryotes.

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[1]

(iii) State **two** differences, **other** than differences in ribosomes, between typical bacterial cells and typical eukaryotic cells.

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[2]

(b) Scientists have estimated the numbers of ribosomes found in cells.

Fig. 1.1 is an electronmicrograph showing ribosomes in a cell.

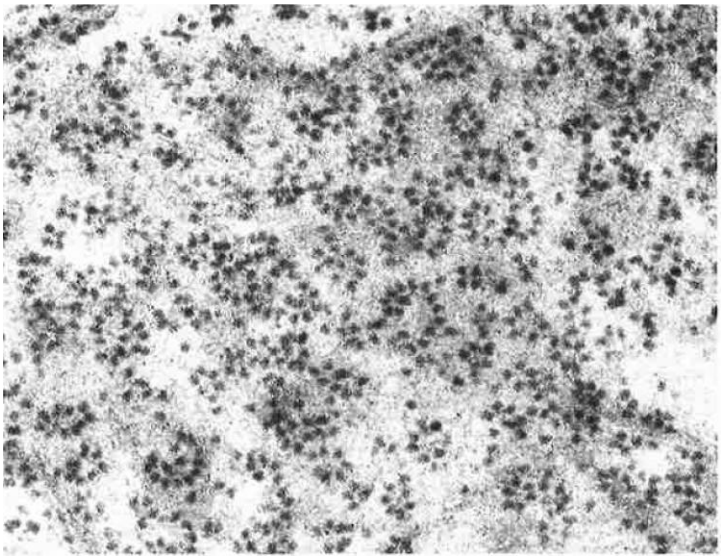

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Fig. 1.1

(i) Suggest why it is difficult to use electronmicrographs, such as that shown in Fig. 1.1, to determine the total number of ribosomes in a cell.

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[3]

(ii) Fig. 1.2 shows data for the number of ribosomes present in cells of different volumes.

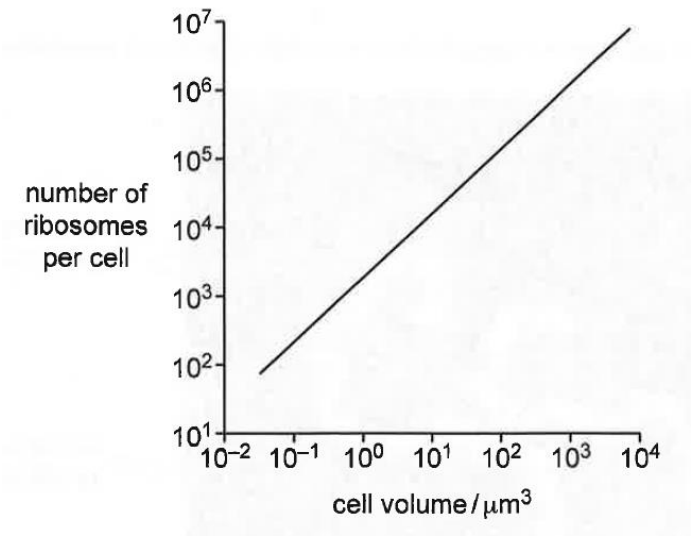

Fig.1.2

Describe **and** explain the relationship shown in Fig. 1.2.

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[3]

[Total: 10]

2 In 1953, James Watson and Francis Crick published details about the structure of DNA. They used experimental results from other scientists to help them work out the structure and then built a model of a section of a DNA molecule, using pieces of wire and metal, with clamp stands to hold the model in place. This is shown in Fig. 2.1.

Fig. 2.1

(a) Watson and Crick used results from work carried out by Erwin Chargaff. He found that the proportions of the bases A, T, C and G were different in different species, but within each species:

- the proportion of A was equal to the proportion of T
- the proportion of G was equal to the proportion of C.

(i) Name the bases A, T, G and C.

A: ..... **T:** .....

C: ..... **G:** .....

[2]

(ii) Suggest **and** explain how Chargaff's findings helped Watson and Crick work out the structure of DNA.

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[3]

(b) Phoebus Levene isolated the nucleotides of DNA and identified the carbohydrate component of each nucleotide.

State the name of this carbohydrate component.

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[1]

(c) Before the discovery of the structure of DNA as the molecule of inheritance, scientists thought that proteins were most likely to be the molecules that carried information.

Suggest how the structure of proteins made scientists think that these were the molecules that carried information.

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[2]

[Total: 8]

3 Leber Congenital Amaurosis (LCA) is an inherited eye disease. In LCA, the photoreceptor cells in the retina die at an early age. This causes impaired vision (reduced eyesight) in children, which can progress to blindness.

LCA10 is a different form of LCA caused by a recessive mutation in the *CEP290* gene. This gene codes for the protein CEP290, which is involved in the correct functioning of photoreceptor cells in the retina.

This mutation in *CEP290* occurs in the intron and causes an error to be made when the primary transcript is spliced to form messenger RNA (mRNA). The abnormal mRNA that is formed has an extra sequence of RNA nucleotides, known as exon X, between exon 26 and exon 27. Exon X contains a STOP codon.

Fig. 3.1 compares the effect of the mutation in CEP290 with the normal gene expression

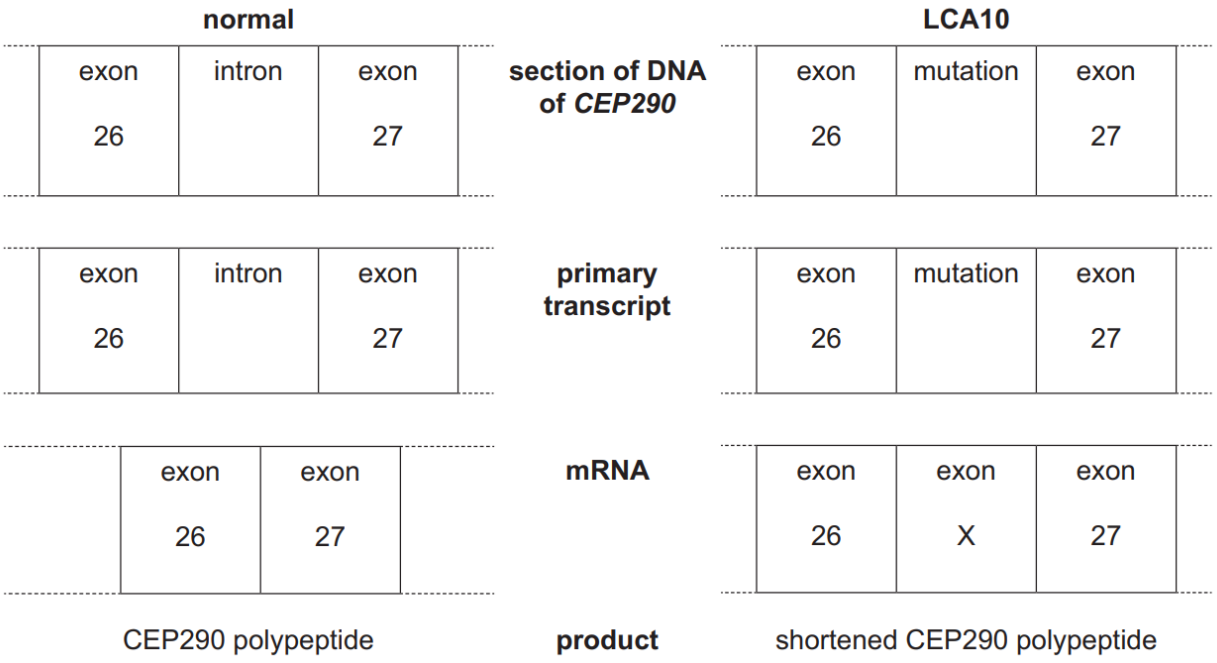

Fig. 3.1

CEP290 is a classic example of intronic mutation, changes in sequences that occur to non-coding DNA.

(a) Define what is non-coding DNA.

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[1]

(b) Describe the structure **and** functions of another **two** types of non-coding DNA in eukaryotes.

[4]

In 2022, research was carried out into possible treatment of LCA10 using genetic technology.

A human clinical trial investigated a treatment of LCA10 using a short RNA nucleotide sequence known as Sepofarsen. Sepofarsen binds to the section of the primary transcript containing the CEP290 mutation.

(c) With reference to the above method, identify the level in which gene regulation is achieved **and** describe two other methods to regulate gene expression at this level and their respective functions.

[5]

[Total: 10]

4 **(a)** Fig. 4.1 shows photomicrographs of individual cells from the root tip of an onion, *Allium sp.*, at different times in the mitotic cell cycle.

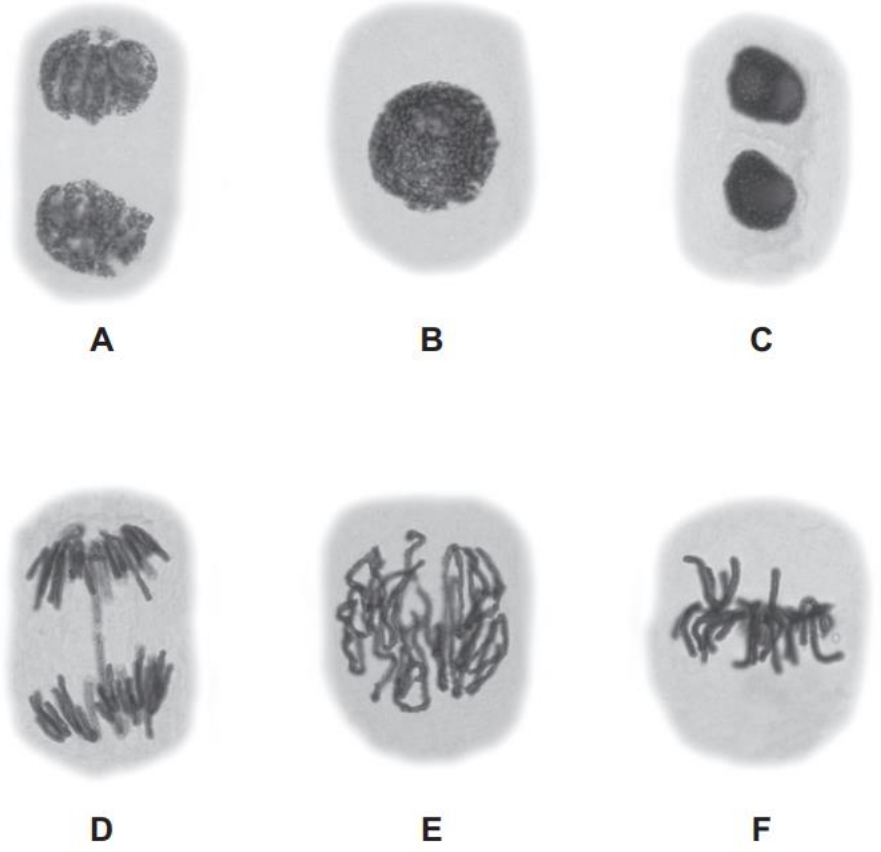

Fig. 4.1

(i) Place the letters representing the individual cells in the correct sequence of the mitotic cell cycle. The first letter has already been filled in.

B					

[2]

(ii) Describe the events that occur in cell **A**.

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[3]

(iii) Colchicine is a chemical used by scientists to study mitosis. This chemical inhibits the organisation of the microtubules in prophase of mitosis.

The cells shown in Fig. 4.1 had not been treated with colchicine.

Explain the evidence in Fig. 4.1 that shows the cells had not been treated with colchicine.

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[2]

(b) Complete Table 4.1 by stating the term that matches each of the descriptions.

Table. 4.1

term	description
	Region of DNA with repeated nucleotide sequences located at the ends of chromosomes
	Organises microtubules to form the spindle in animal cells
	Point of attachment between two sister chromatids

[3]

[Total: 10]

5 A student crossed a tan-bodied *Drosophila* fly with a yellow-bodied *Drosophila* fly, expecting to get an F1 generation of all tan-bodied flies. Body colour for *Drosophila* flies are sex-linked. The tan-body allele (T) is known to be dominant over the yellow-body (t) allele. In *Drosophila*, the males are the heterogametic sex, possessing two different sex chromosomes, X and Y. The results from the cross are shown in Table 5.1.

Table 5.1

Phenotype of fly	Number of offspring
tan-bodied female	27
tan-bodied male	0
yellow-bodied female	0
yellow-bodied male	23

(a) **(i)** With reference to Table 5.1, describe crosses that can be carried out to determine if body colour is autosomal or sex-linked.

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[3]

(ii) Draw a genetic diagram to show how the results shown in Table 5.1 could have been produced.

[3]

(b) The eye colour in *Drosophila* fly is determine by two genes, gene A/a and gene B/b. A homozygous wild type fly with brick-red eyes was crossed with a homozygous fly with white eyes. All the F_1 offspring were wild types with brick-red eyes. When the F_1 offspring were mated to each other, the F_2 generation was observed as follows:

Wildtype eyes (brick-red)	938
Scarlet eyes (bright red)	286
Brown eyes	315
White eyes	89

(i) The genotype for wildtype eyes have been filled in, in the table below. Suggest a suitable genotype for each of the remaining phenotypes.

Phenotype	Genotype
Wildtype eyes (brick-red)	A_B_
Scarlet eyes (bright red)	
Brown eyes	
White eyes	

[3]

(ii) A chi-squared test was carried out on the results of the second cross.

Phenotype	Observed number (O)	Expected number (E)	$\frac{(O-E)^2}{E}$
Wildtype eyes (brick-red)	938	915.75	0.54
Scarlet eyes (bright red)	286	305.25	1.21
Brown eyes	315	305.25	0.31
White eyes	89	101.75	1.60

The χ^2 test gave a value = 3.66, with 3 degrees of freedom.

Part of the critical values of the chi-squared distribution is shown below.

Distribution of χ^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

Explain if the difference between the observed and expected is significant.

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[2]

[Total: 11]

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6 Adrenaline is a signal molecule that stimulates similar cellular responses from liver cells and adipose cells in a way similar to that of glucagon.

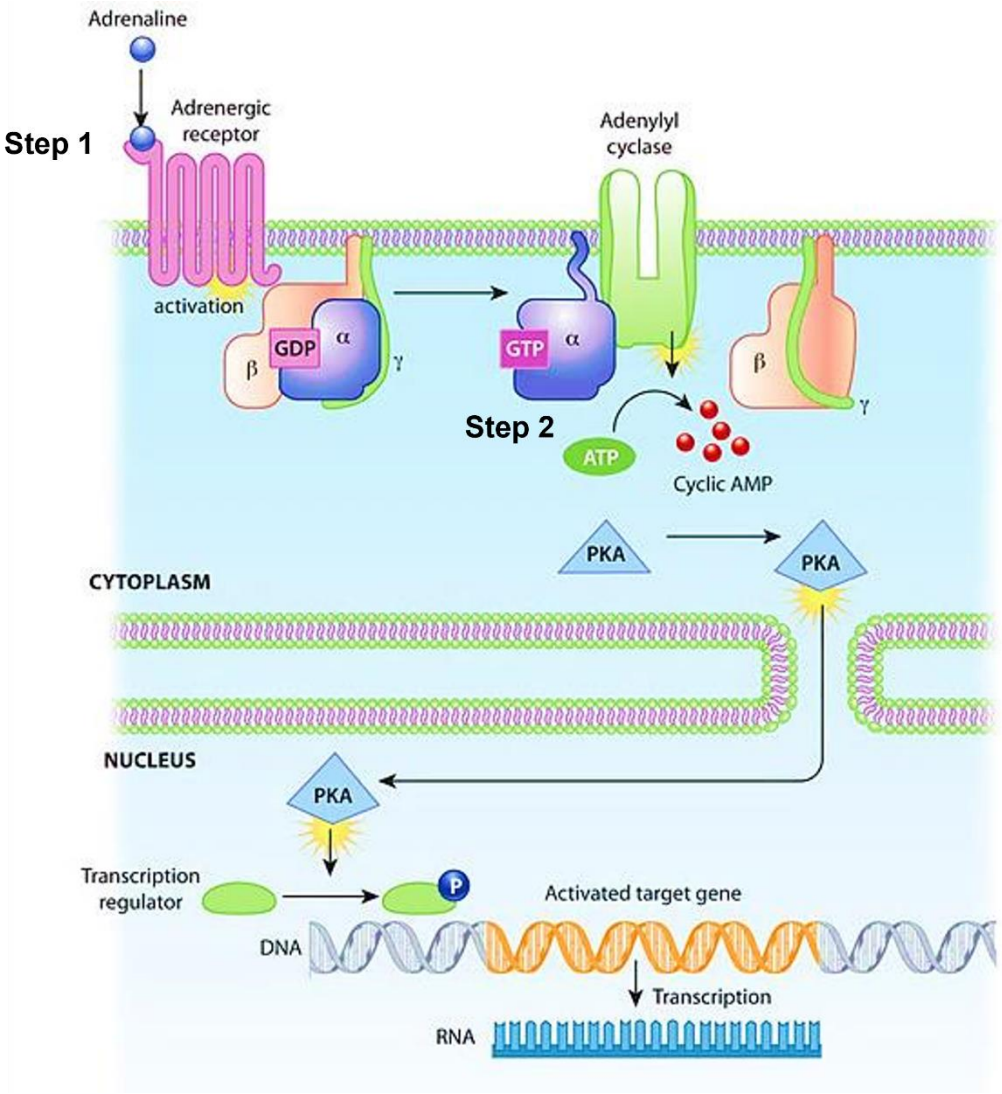

Fig. 6.1

(a) With reference to Fig. 6.1,

(i) describe the events occurring in **step 1** after the binding of adrenaline molecule to the adrenergic receptor.

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[2]

(ii) explain the significance of **step 2** that results in effective signal transduction.

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(iii) describe the series of events that occur after the activation of protein kinase A that results in a cellular response.

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[3]

(b) A mutation resulted in high concentration of cyclic AMP being produced in the liver cell.

Assuming that the adenylyl cyclase functions normally, explain how a mutation can lead to the observation above.

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[2]

[Total: 10]

7 The light-dependent stage of photosynthesis occurs within chloroplasts. In this stage, electrons are emitted from the special chlorophyll *a* molecules and passed to electron acceptors.

If a redox indicator, such as DCPIP, is added to a suspension of illuminated chloroplasts, electrons will be transferred to DCPIP, causing the colour of the DCPIP to change from blue to colourless.

A student investigated the effect of the wavelength of light (colour of light) on the rate of photosynthesis.

- DCPIP was added to three colorimeter tubes, each containing a suspension of chloroplasts. The chloroplast suspensions were kept in the dark until required.

- The colorimeter tubes were each exposed to light of a different colour: red, blue or green. The intensity of light was the same for all tubes, and each was exposed to light for four minutes. All other conditions were kept the same.

- The absorbance of each chloroplast suspension was measured at one-minute intervals using a colorimeter.

The results are shown in Fig. 7.1.

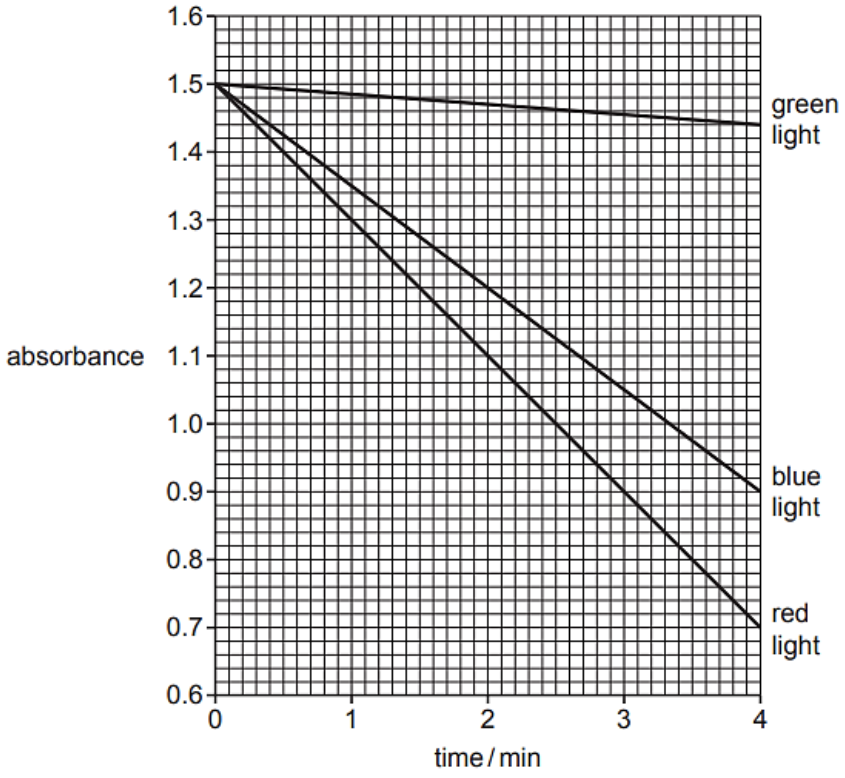

Fig. 7.1

(a) **(i)** Explain why the chloroplast suspensions were kept in the dark until required.

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[1]

(ii) Describe the results shown in Fig. 7.1.

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[3]

(iii) With reference to the light-dependent stage of photosynthesis, explain the differences between the results shown in Fig. 7.1 for red light and for green light.

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[3]

(b) Changes in the atmospheric carbon dioxide concentration, light intensity and temperature can affect the rate of photosynthesis. These three factors directly affect different processes of photosynthesis.

Complete Table 7.1 using a tick (✓) to identify the processes that can be **directly** affected by each factor or a cross (✗) to identify the processes that are **not directly** affected by each factor.

Indirect effects where a change in the rate of one process affects the rate of a different process should **not** be considered.

A tick or a cross must be placed in the final column of every row.

Table 7.1

factor	process	✓ or ✗
carbon dioxide concentration	Calvin cycle	.....
	photophosphorylation	.....
light intensity	Calvin cycle	.....
	photophosphorylation	.....
temperature	Calvin cycle	.....
	photophosphorylation	.....

[3]

[Total: 10]

8 Fig. 8.1 shows the reproductive cycle of Human Immunodeficiency Virus (HIV).

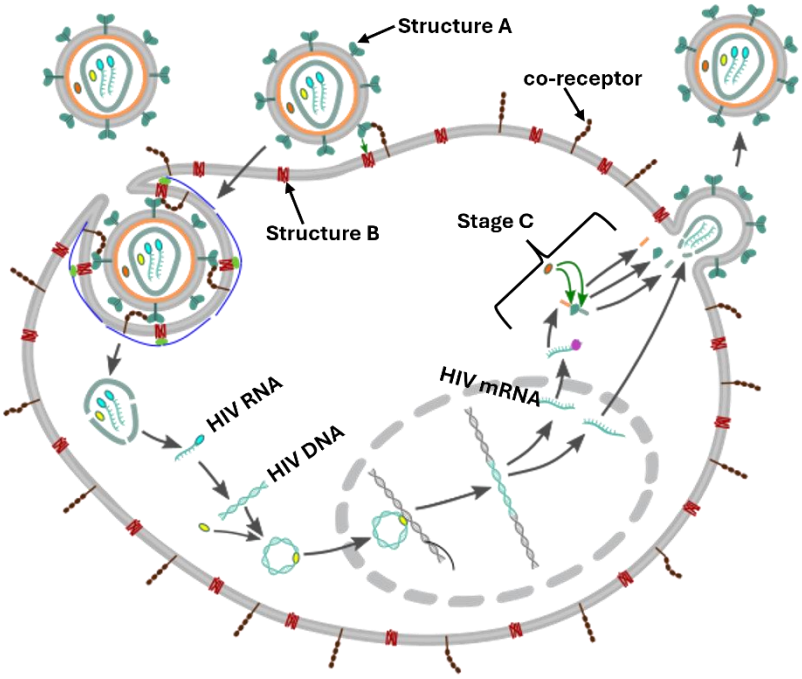

Fig. 8.1

(a) Name structures **A** and **B**.

A .....

B .....

[2]

(b) Describe the events occurring in Stage **C** leading to the formation of Structure **A** on the host cell surface membrane.

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(c) Explain why enveloped viruses such as HIV will not exit their host cells the same way as the T4 bacteriophage.

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(d) Besides the structures shown in Fig. 8.1, state two other components of the viral envelope.

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[Total: 10]

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9 *Spea multiplicata* is one of several species of American spadefoot toad.

(a) Young spadefoot toads are called tadpoles and live in water in ponds.

S. multiplicata tadpoles show three different phenotypes due to genetic variation. The three phenotypes are: detritus feeder, intermediate and carnivore.

Detritus feeders are small, and carnivores are large. Intermediates vary in size between the two extremes.

A detritus feeder and a carnivore are shown in Fig. 9.1.

Fig. 9.1

Detritus feeders:
- eat detritus (small pieces of dead organic matter) and algae (photosynthetic protoctists)
- have smooth mouthparts, small jaw muscles and long intestines.

Intermediates:
- can eat all available food (detritus, algae and fairy shrimps)
- have teeth-like mouthparts, medium-sized jaw muscles and medium-sized intestines.

Carnivores:
- eat fairy shrimps and other small animals
- have teeth-like mouthparts, large jaw muscles and short intestines.

Scientists counted the number of each type of tadpole in two different ponds: pond 1 and pond 2.

(i) In pond 1, the scientists observed:

- a high density of tadpoles
- a low abundance of food
- that most of the tadpoles they counted were either detritus feeders or carnivores, with very few intermediates present.

Describe and suggest explanations of natural selection that appears to be acting in pond 1.

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[2]

(ii) In pond 2, the scientists observed:

- a low density of tadpoles
- sufficient food availability for all tadpoles
- that most of the tadpoles they counted were intermediates, with fewer detritus feeders or carnivores.

Describe and suggest explanations of natural selection that appears to be acting in pond 2.

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[2]

(iii) State the type of variation shown by the intestine length of *S. multiplicata* tadpoles and list the factors that lead to this type of variation.

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[2]

(iv) A student suggested that the variation in *S. multiplicata* tadpoles could lead to speciation in some populations.

Outline the feature of **one** concept of species and its limitation.

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[2]

(b) Fig. 9.2 shows the evolutionary relationships between three species of American spadefoot toad.

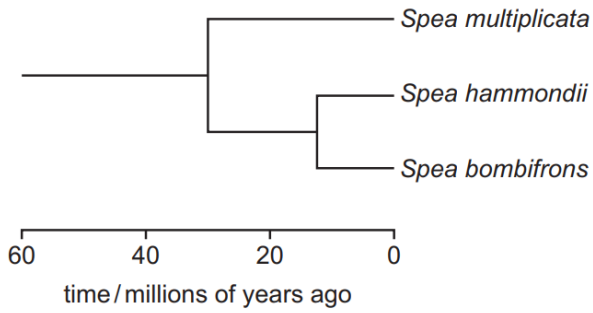

Fig. 9.2

Explain how analysis of DNA allowed the evolutionary relationships shown in Fig. 9.2 to be determined.

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[2]

[Total: 10]

10 Fig. 10.1 shows a process that occurs naturally in a B cell.

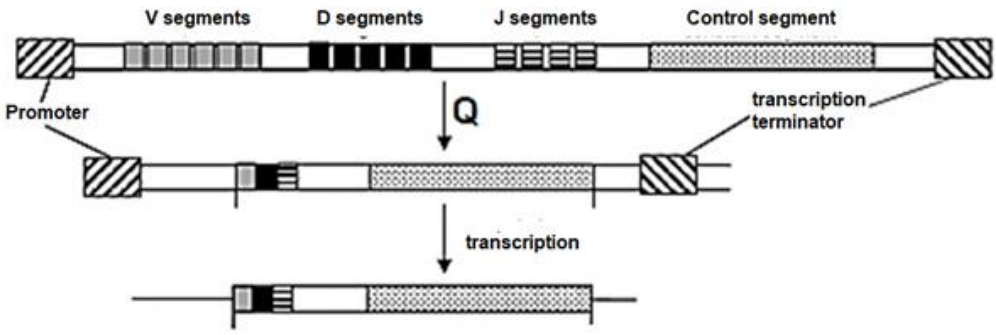

Fig. 10.1

(a) State precisely where the process shown in Fig. 10.1 occurs in the human body.

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[1]

(b) Explain why Process Q is essential to maintaining the health of an individual.

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[3]

(c) Besides the location, describe two differences between process Q and class switching.

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[2]

[Total: 6]

11 The two-spot ladybird, *Adalia bipunctata*, is a species of small, flying beetle that is found in northern Europe and other parts of the world. The wings of these beetles are covered by two tough structures known as elytra, as shown in Fig. 11.1.

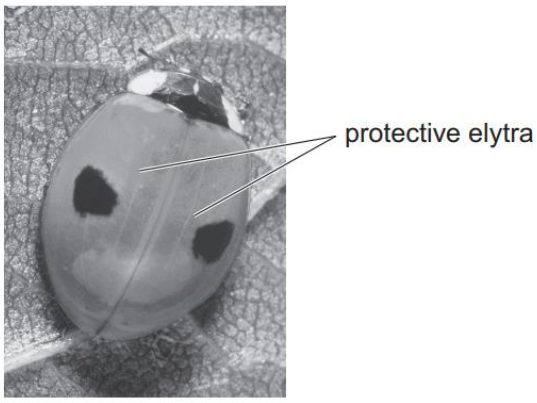

Fig. 11.1

The elytra of *A. bipunctata* show phenotypic variation. The three most common morphs (forms) found in northern Europe are known as typica (**T**), quadrimaculata (**Q**) and sexpustulata (**S**).

- The typica morph, shown in Fig. 11.1, is mostly red with two black spots and is described as non-melanic.
- The other two morphs are described as melanic as they are mainly black with some red.
- The distribution of the colours in these three morphs is shown in Fig. 11.2.

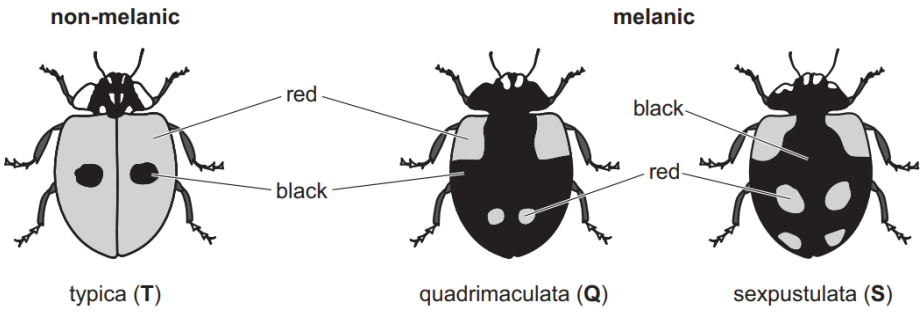

Fig. 11.2

Environmental temperature is one of many different selection pressures that could be acting on populations of *A. bipunctata*. The melanic phenotypes, morphs **Q** and **S**, are considered to be better adapted to the climate in northern Europe as they absorb heat energy more readily than the non-melanic phenotype, morph **T**.

Scientists investigated the effect of temperature on the body temperature of the two different phenotypes.

- The four individuals used in the investigation were collected while they were hibernating (inactive) during winter and were kept outdoors for six weeks before the investigation.
- The individuals were weighed and arranged into pairs, each with approximately the same mass.
- A temperature sensor was fixed to the lower (ventral) surface of each individual.
- The temperature of each individual was recorded for 9 minutes. During that time, a heat-emitting lamp positioned directly above the individuals was switched on at 30s and switched off at 5 minutes.

The results are shown in Fig. 11.3.

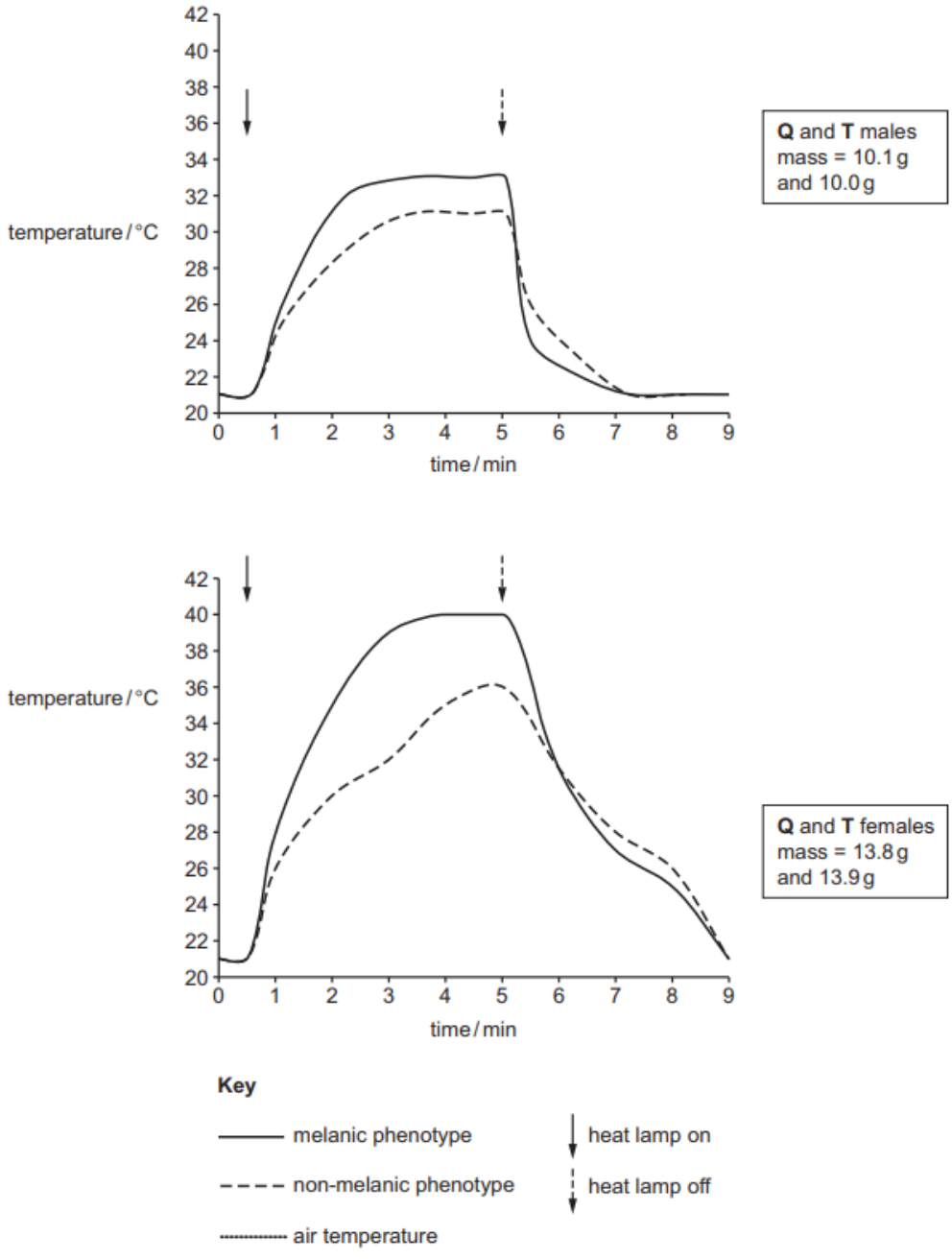

Fig. 11.3

(a) The researchers concluded that melanic morphs warm up more quickly than non-melanic morphs. Explain how the information shown in Fig. 11.3 supports this conclusion.

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[1]

(b) Explain how global warming might affect the population and distribution of these ladybirds.

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[3]

(c) Suggest why female ladybirds are heavier in mass when compared to the male ladybirds.

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[1]

[Total: 5]