



EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examinations 2025
General Certificate of Education Advanced Level
Higher 2

CANDIDATE
NAME

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CIVICS
GROUP

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REGISTRATION
NUMBER

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H2 Biology

9744/03

Paper 3 Long Structured and Free-response Questions

17 September 2025

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 your answers 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/tape.

Section A

Answer **all** questions on the **Question Paper**.

Section B

Answer **one** question on the **12-page Answer Booklet** provided.

Write your answer to each part of the question on a fresh sheet of paper.

The use of an approved scientific calculator is expected, where appropriate.

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

At the end of the examination, ensure that you submit both the Question Paper and Answer Booklet.

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
4 OR 5	
Total	75

This document consists of **18** printed pages and **2** blank pages.

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Section A

Answer **all** questions on the Question Paper.

- 1 Fig. 1.1 is a diagram showing the transcription of part of the *CALD1* gene that codes for a protein known as caldesmon. The part of the *CALD1* gene shown is a section of exon. Structure **A** represents an enzyme involved in transcription.

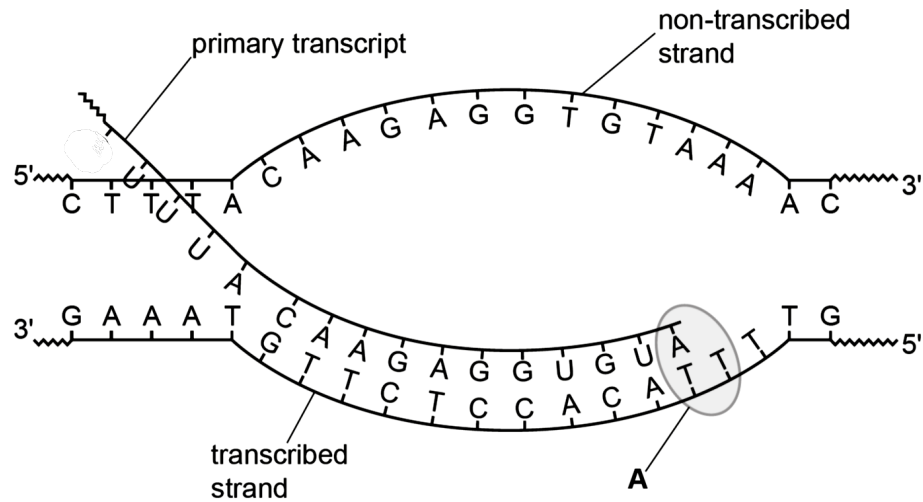


Fig. 1.1

- (a) (i) Name the enzyme labelled **A** in Fig. 1.1.

..... [1]

- (ii) Name the bond that forms between the nucleotides in the primary transcript.

..... [1]

Table 1.1 shows the codons that correspond to some amino acids.

Table 1.1

amino acid	codons
Phe	UUU UUC
Trp	UGG
Met	AUG
Thr	ACU ACC ACA ACG
Arg	AGA AGG
Val	GUU GUC GUA GUG
Gly	GGU GGC GGA GGG

- (iii) State the amino acid sequence that is coded for by the sequence of nucleotides on the primary transcript shown in Fig. 1.1.

..... [1]

(iv) Explain why one of the strands of DNA is **not** transcribed.

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..... [3]

Caldesmon is a large protein with a number of binding sites to attach to other proteins.

Caldesmon exists in two different forms, H-caldesmon and L-caldesmon.

H-caldesmon helps to regulate contraction and relaxation in smooth muscle cells.

L-caldesmon is found in some non-muscle cells, where it also acts as a regulatory protein.

- Caldesmon is coded for by a gene known as *CALD1*.
- *CALD1* has 17 exons.
- The primary structure of H-caldesmon has a repeating sequence in the middle of the amino acid chain that is **not** present in L-caldesmon.

(b) (i) Researchers have discovered that a gene mutation is **not** the cause of the two different forms of caldesmon.

Explain what is meant by a gene mutation.

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..... [2]

- (ii) Researchers now know that the two different forms of caldesmon are the result of events occurring **directly after** transcription of DNA. Changes occur to the primary transcript that is formed by DNA transcription.

Explain how the smooth muscle cells and non-muscle cells can produce different forms of caldesmon from the same primary transcript.

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..... [2]

- (iii) Suggest how the two different forms of caldesmon can still have similar functions, even though they have a different primary structure.

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..... [1]

Caldesmon was recently reported in the scientific literature to be involved in gastric cancer progression, invasion, and migration.

Tumour cells can become invasive through increased mobility and decreased adhesion, which can lead to metastasis from the primary tumour site. This process is triggered through changes in gene expression mediated by signalling pathways, including the PI3K-AKT pathway.

Fig. 1.2 shows the PI3K-AKT signalling pathway, in which:

- KRAS and RHEB are G-proteins.
- PI3K, AKT, RAF, MEK, and ERK are all protein kinases.
- Sharp arrows ($\downarrow$) represent activation, while blunt arrows ($\perp$) represent inhibition.

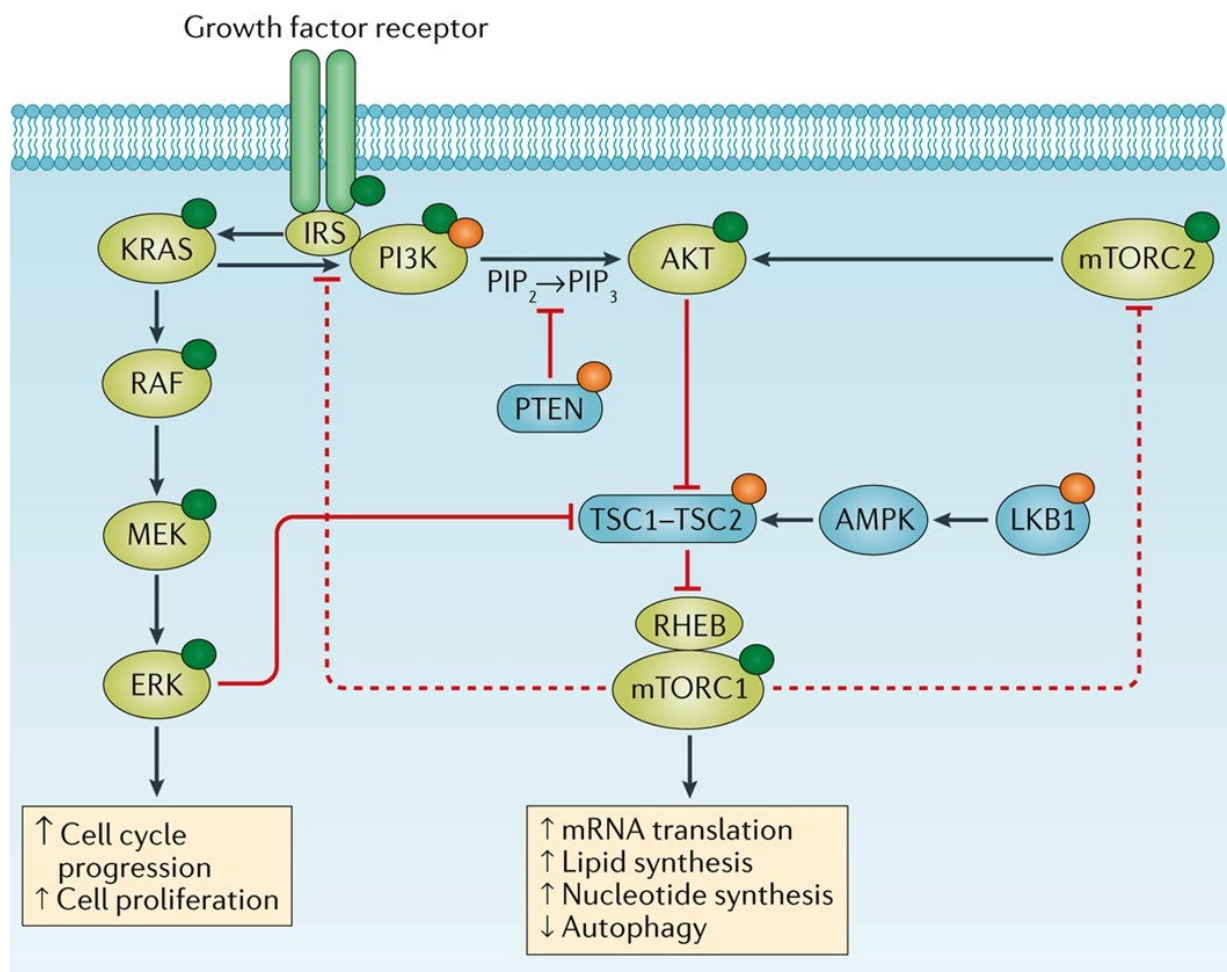


Fig. 1.2

- (c) (i) Other than signal amplification, describe **one** advantage of the PI3K-AKT signalling pathway using one example shown in Fig. 1.2.

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..... [2]

- (ii) Using Fig. 1.2, describe a phosphorylation cascade that results in cell cycle progression.

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..... [2]

- (d) Describe the role of second messengers.

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..... [2]

ERK induces the expression of two transcription factors, Jun and Fos. These are both reported in the scientific literature to be involved in the control of the mitotic cell cycle.

Cyclin-dependent kinases (CDKs) are enzymes involved in the control of the mitotic cycle. The gene *CDKB2* codes for one of these kinase enzymes. Genes *KRP4* and *CycD6* code for proteins that regulate the activity of CDKs.

The scientists investigated the effect of Jun and Fos on gene expression. They measured the relative quantities of mRNA produced by transcription of the three genes, *CDKB2*, *KRP4*, and *CycD6*. Fig. 1.3 shows the effects of Jun alone, Fos alone, as well as Jun and Fos combined on the expression of the three genes. Error bars show **standard deviation** ($n = 3$).

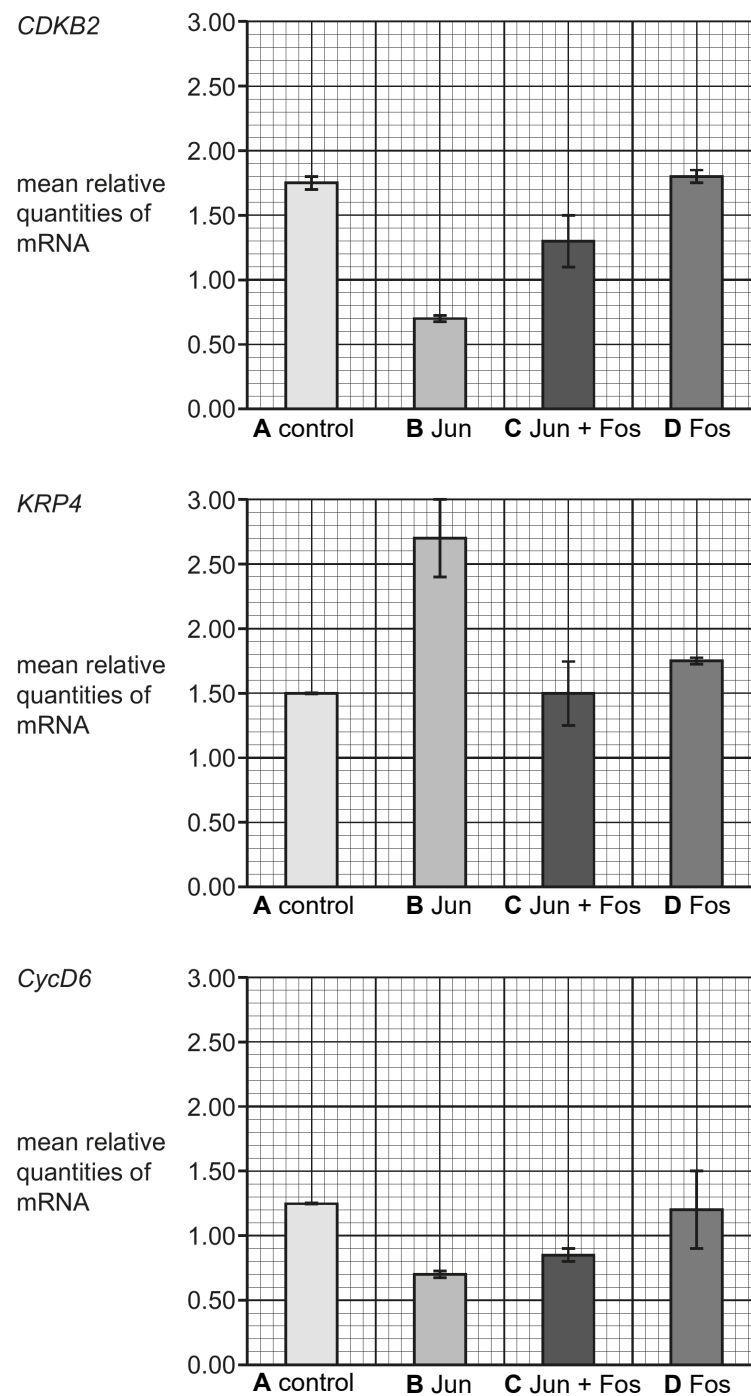


Fig. 1.3

- (e) (i) Complete Table 1.2 to show how the expression of the three genes is affected by the presence of Jun alone and Fos alone, shown in Fig. 1.3.

Use **only** these descriptions to complete the table:

large increase small increase no change small decrease large decrease

Table 1.2

gene	effect of gene expression	
	Jun only	Fos only
<i>CDKB2</i>		
<i>KRP4</i>		
<i>CycD6</i>		

[3]

- (ii) Fig. 1.3 also shows the combined effect of Jun and Fos (**C**) on the expression of the three genes.

The scientists made two conclusions about the effects of the mixture of Jun and Fos (**C**) on the expression of the genes *KRP4* and *CycD6*.

Conclusion 1: Fos counteracts the stimulation of gene expression of *KRP4* by Jun.

Conclusion 2: Fos does not reverse the effect of Jun on gene expression of *CycD6*.

State **and** explain whether the evidence from Fig. 1.3 **fully supports**, **partially supports** or **does not support** each of these conclusions.

conclusion 1

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conclusion 2

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..... [2]

The relative quantities of mRNA shown in Fig. 1.3 were derived using a modified form of PCR.

Fig. 1.4 shows how mRNA is first used to form complementary DNA (cDNA), which is subsequently amplified by PCR.

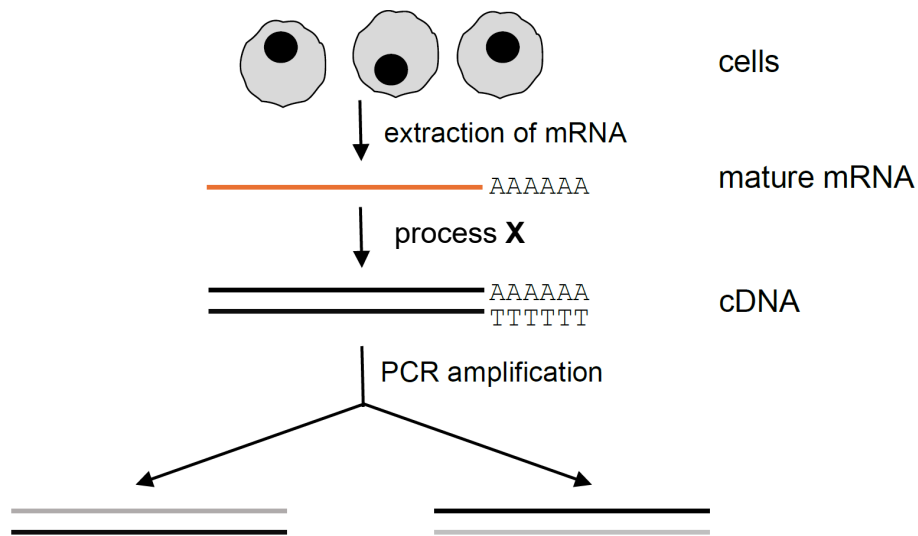


Fig. 1.4

- (f) (i) State the name of the enzyme that catalyses process X.

..... [1]

- (ii) Suggest why RNA cannot be used directly in PCR amplification without first undergoing process X.

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 [1]

mRNA produced from transcription of *Jun* was amplified using the process shown in Fig. 1.4.

Amplified *Jun* cDNA fragments from two different individuals were subjected to gel electrophoresis and nucleic acid hybridisation.

Fig. 1.5 shows the results of a healthy individual and a cancer patient.

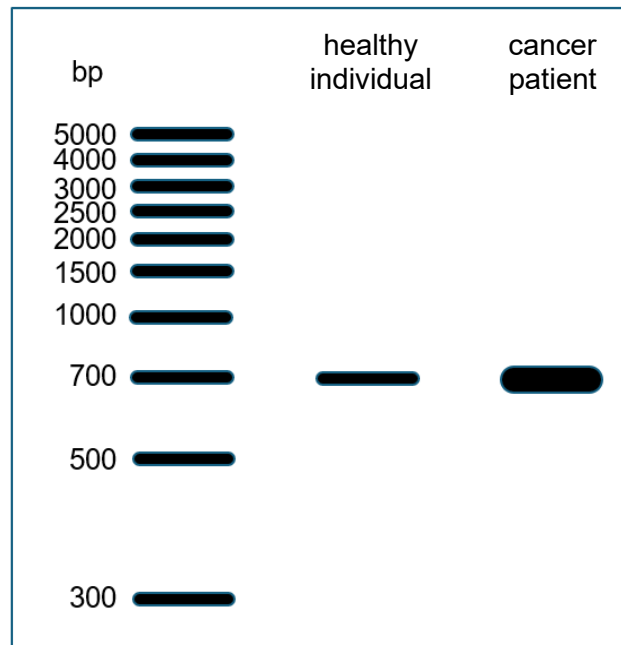


Fig. 1.5

- (g) (i) With reference to Fig. 1.5, describe the difference in relative quantities of *Jun* cDNA, and explain how nucleic acid hybridisation was used to investigate this.

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..... [4]

- (ii) Genes that are typically involved in cancer development are classified as either proto-oncogenes or tumour suppressor genes.

Suggest and explain which type of gene *Jun* may be.

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..... [2]

[Total: 30]

2 One of the proteins found in milk is β -casein.

A molecule of β -casein consists of a single polypeptide of approximately 200 amino acids.

Molecules of β -casein have a **high** proportion of the amino acids proline and leucine. These amino acids have hydrophobic R groups.

Fig. 2.1 compares the structure of proline with the general structure of an amino acid. Proline is an unusual amino acid because it has a cyclic R group and the nitrogen atom is attached to only one hydrogen atom.

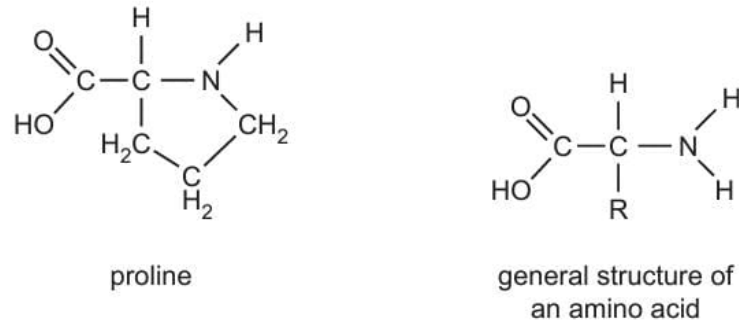


Fig. 2.1

- (a)** Using the general structure of an amino acid shown in Fig. 2.1, show how two amino acids are joined together.

[3]

- (b) When a molecule of proline becomes part of a polypeptide, the hydrogen atom is lost from the nitrogen atom and is therefore **not** available for the formation of hydrogen bonds.

Compared to other protein molecules with a similar number of amino acids, β -casein molecules have a much less organised secondary structure.

Suggest why is this so.

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.....[4]

Molecules of β -casein have a relatively **low** proportion of amino acids cysteine and serine. Table 2.1 shows the R groups of cysteine and serine.

Table 2.1

amino acid	R group
cysteine	- CH ₂ SH
serine	- CH ₂ OH

(c) Using Table 2.1,

(i) state the level of protein structure that the R group of serine helps to maintain;

.....[1]

(ii) explain how serine contributes to the level of protein structure specified in your answer to **(c)(i)**.

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[2]

[Total: 10]

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

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. 3.1.



Fig. 3.1

Detritus feeders:

- eat detritus (small pieces of dead organic matter) and algae
- 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.

(a) (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 for the type of natural selection that appears to be acting in pond 1.

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.....[3]

(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 for the type of natural selection that appears to be acting in pond 2.

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.....[3]

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

Outline the features of sympatric speciation.

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.....[2]

- (b) Fig. 3.2 shows the evolutionary relationships between three species of the American spadefoot toad.

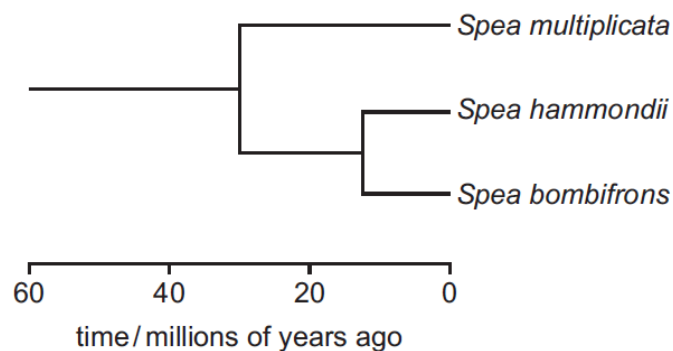


Fig. 3.2

Explain how analysis of DNA allowed the evolutionary relationships shown in Fig. 3.2 to be determined.

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.....[2]

[Total: 10]

Section B

Answer **one** question in this section.

Write your answers on the Answer Booklet provided.

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.

- 4 (a)** Explain the importance of non-coding sequences in eukaryotes. [14]

- (b)** Dinosaurs are now extinct but there are approximately 10,000 species of living birds. It is thought that birds evolved from small dinosaurs and that being small helped their survival during a time of rapid environmental change when species of large dinosaurs went extinct.

Suggest and explain why, in a rapidly changing environment, small animals may possess evolutionary advantages compared to large animals. [11]

[Total: 25]

- 5 (a)** Many enzymes are proteins, but not all proteins are enzymes.

Using examples, explain the importance of non-enzymatic proteins that are found embedded in membranes. [14]

- (b)** Immunity can be described as passive, active, naturally acquired or artificially acquired.

Discuss how antibodies illustrate these forms of immunity, and explain why antibodies are considered part of the specific immune system. [11]

[Total: 25]

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