H

**RAFFLES INSTITUTION**

**2015 Year 6 Preliminary Examination**
Higher 2

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| CANDIDATE NAME | |

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| CIVICS GROUP | 1 | 5 | S | 0 | 3 | | INDEX NUMBER | | | | | | |

# BIOLOGY

Paper 2 Core paper

**9648/02**
**16th SEPTEMBER 2015**
**2 hours**

Additional materials: Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write your index number, CT group & name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
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.

**Section B**

Answer **either ONE** question.

At the end of the examination, **hand in your essay SEPARATELY.**
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/ 9** |
| **2** | **/10** |
| **3** | **/12** |
| **4** | **/10** |
| **5** | **/10** |
| **6** | **/ 9** |
| **7** | **/ 9** |
| **8** | **/11** |
| **Section B** | |
| **9 or 10** | **/20** |
| **Total** | **/100** |

This document consists of **24** printed pages.

For Examiner's Use

## Section A

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

**1** Meristematic root tissue from a barley seedling was prepared and its chromosomes were observed under a microscope. **Fig. 1.1** shows a cell from the root tissue at the metaphase stage of mitosis.

**Fig. 1.1**

**Fig. 1.2** shows the changes in amount of DNA at different stages of the barley life cycle.

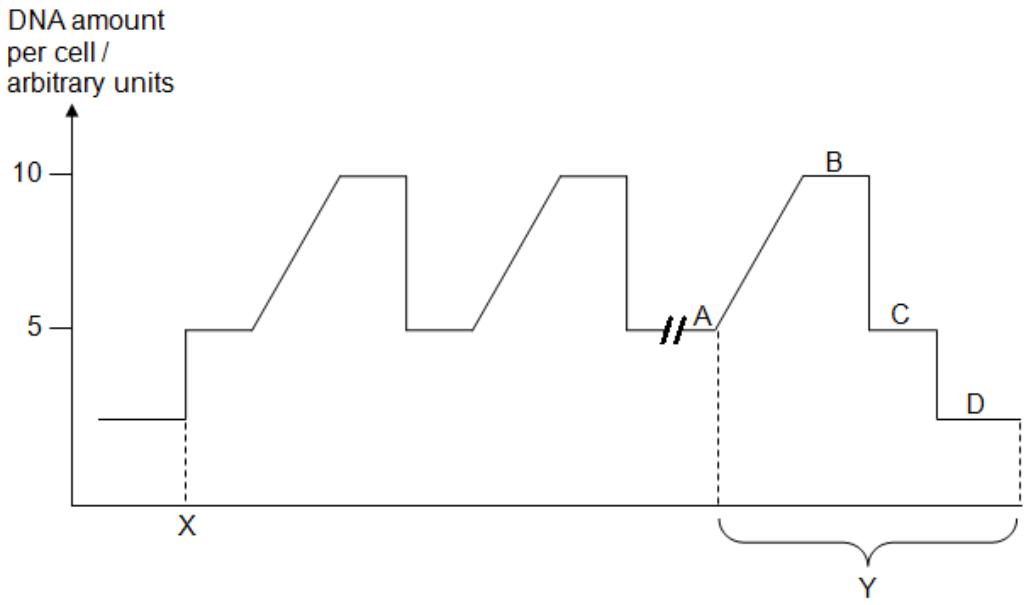


**Fig. 1.2**

**(a)** Mark out clearly with an arrow, ↓, on **Fig 1.2**, the part of the graph which corresponds to the stage shown in **Fig. 1.1**. [1]

**(b)** With reference to **Fig. 1.2**, state which of the stages, from **A** to **D**,

**(i)** has/have the **same** number of chromosomes as shown in **Fig. 1.1**; [1]

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**(ii)** has/have a **different** number of chromosomes as shown in **Fig. 1.1**. [1]

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**(c)** Explain how stages in **Y** lead to variation. [4]

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**(d)** Explain the significance of the event occurring at **X**. [2]

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[Total : 9]

For Examiner's Use

**2** **Fig. 2.1** shows DNA replication.

(a)(i)

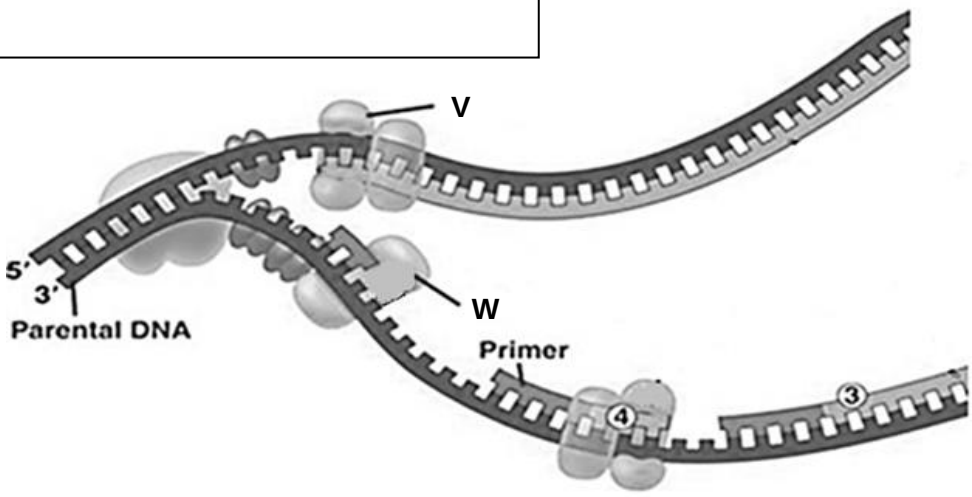


**Fig. 2.1**

**(a)** **(i)** Use an arrow to show the direction of replication of the leading strand in the box provided in **Fig. 2.1**. [1]

**(ii)** What do **5'** and **3'** on the DNA molecule represent? [2]

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**(iii)** Name the following molecules. [1]

**V:** .....

**W:** .....

**(iv)** Describe the role of two named enzymes that are required for DNA replication. [2]

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**Fig. 2.2** shows transcription**.**

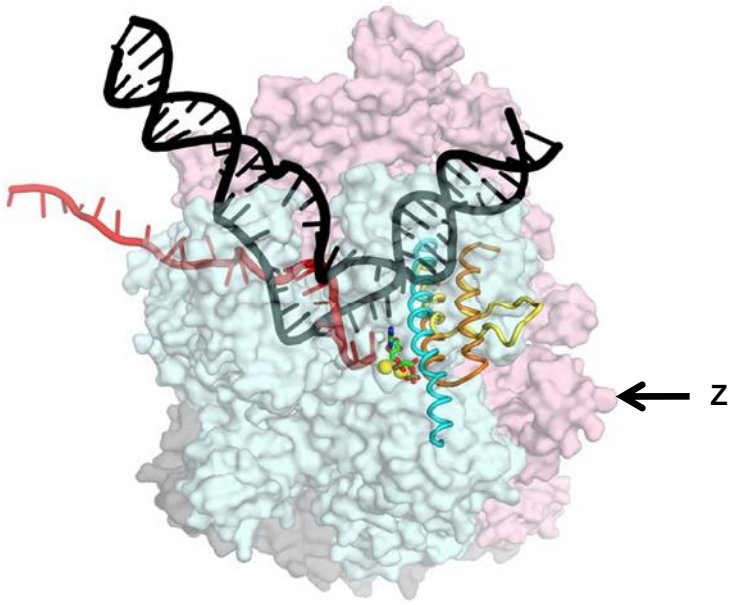


**Fig. 2.2**

**(b)** Describe how the structure of molecule **Z** is adapted to its role in transcription. [2]

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**(c)** Describe how a silent mutation can result in no change in protein structure. [2]

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[Total : 10]

For Examiner's Use

**3** The Jacob-Monod hypothesis describes lactose metabolism in the bacterium *Escherichia coli*. An investigation of this reaction in *E. coli*, at 25°C, was carried out as described below (refer to **Fig. 3.1**).

- 100 $cm^3$ of gel beads coated with *E. coli* were placed into each of seven identical funnels fitted with outlet taps.
- 100 $cm^3$ of solution containing 2 grams of lactose was poured into each funnel at 0 min.
- At each time shown in the table, the solution from the respective funnel was released and collected.
- The mass of lactose in each solution was measured.

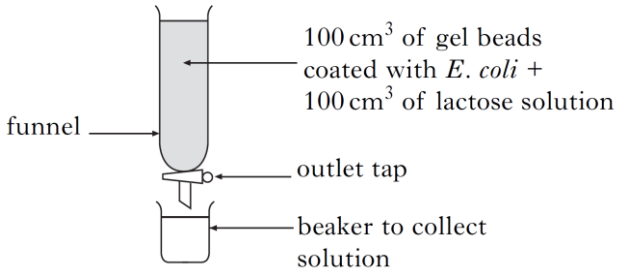


**Fig. 3.1**

The results are shown in **Table 3.1** below.

**Table 3.1**

| Funnel | Time (min) | Mass of lactose collected in the solution (g) |
|---|---|---|
| 1 | 0 | 2.00 |
| 2 | 10 | 2.00 |
| 3 | 20 | 1.48 |
| 4 | 30 | 0.92 |
| 5 | 40 | 0.40 |
| 6 | 50 | 0.12 |
| 7 | 60 | 0.04 |

With reference to **Table 3.1**,

**(a) (i)** calculate the average mass of lactose broken down per minute in funnel 5. [1]

..... g per minute

**(ii)** explain the results from funnels 3 to 7. [4]

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**Fig. 3.2** below shows an operon that controls a catabolic reaction in *E. coli*. Some information on how this operon functions is also provided.

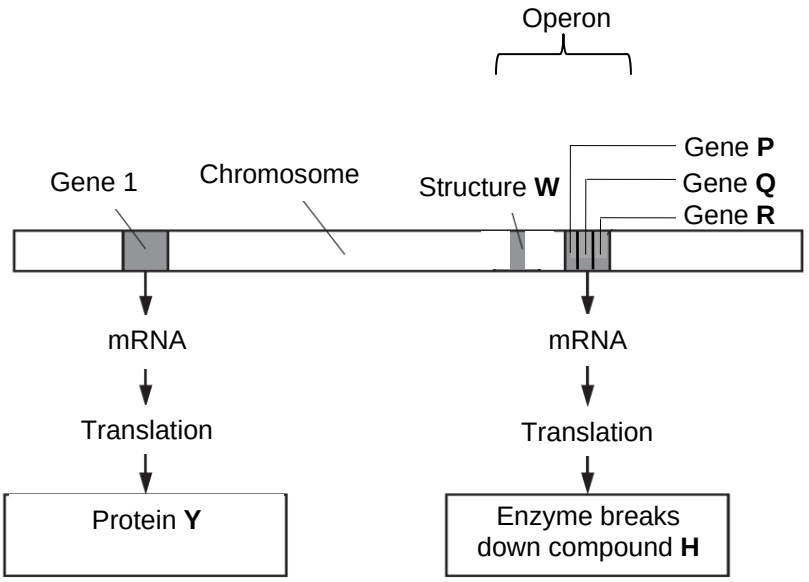


**Fig. 3.2**

**(b) (i)** In the presence of inducer, protein **Y** cannot bind to structure **W**. Name **W**. [1]

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**(ii)** A mutation occurred in gene **P**. This resulted in the production of a truncated protein. Assuming that the inducer is present, explain if the proteins encoded by Gene **Q** and Gene **R** are produced. [2]

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**(c)** An *E. coli* cell can be infected by a bacteriophage. How does the bacteriophage differ from HIV (human immunodeficiency virus) in the way its genome enters the host cell? [1]

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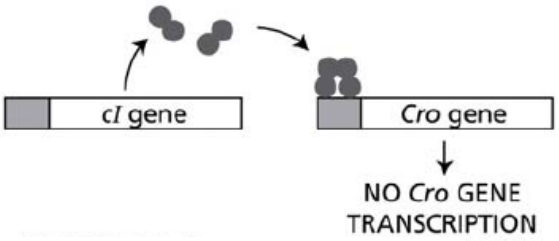
**(d)** Bacteriophage lambda in an *E. coli* cell can replicate as a prophage or lytically. These two phases are controlled by the gene regulatory proteins cI and Cro, which are encoded by the virus (refer to **Fig. 3.3**).

A) Replicate as a prophage




B) Replicate lytically

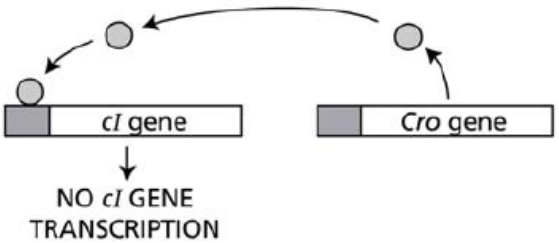



**Fig. 3.3**

When bacteria containing a lambda prophage are irradiated with ultraviolet light, the cI protein is degraded.

With reference to **Fig. 3.3**,

**(i)** state which phase the bacteriophage enters upon UV irradiation, [1]

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**(ii)** describe the events following the degradation of the cI protein. [2]

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[Total : 12]

**4** Glucocorticoids (**S**), are a class of steroid hormones that bind to the glucocorticoid receptor (**GR**), and are crucial in regulation of many genes. **S** binds to **GR**, activating **GR**. Activated **GR** binds to glucocorticoid response elements (**GRE**s) within the promoter regions of target genes. This results in the recruitment of the chromatin remodelling complex, **BRG1** complex.

**Fig. 4.1** shows the effect of **GR**-mediated gene expression. **Fig. 4.2** shows the effect of **BRG1** complex binding to the promoter region of the target gene.

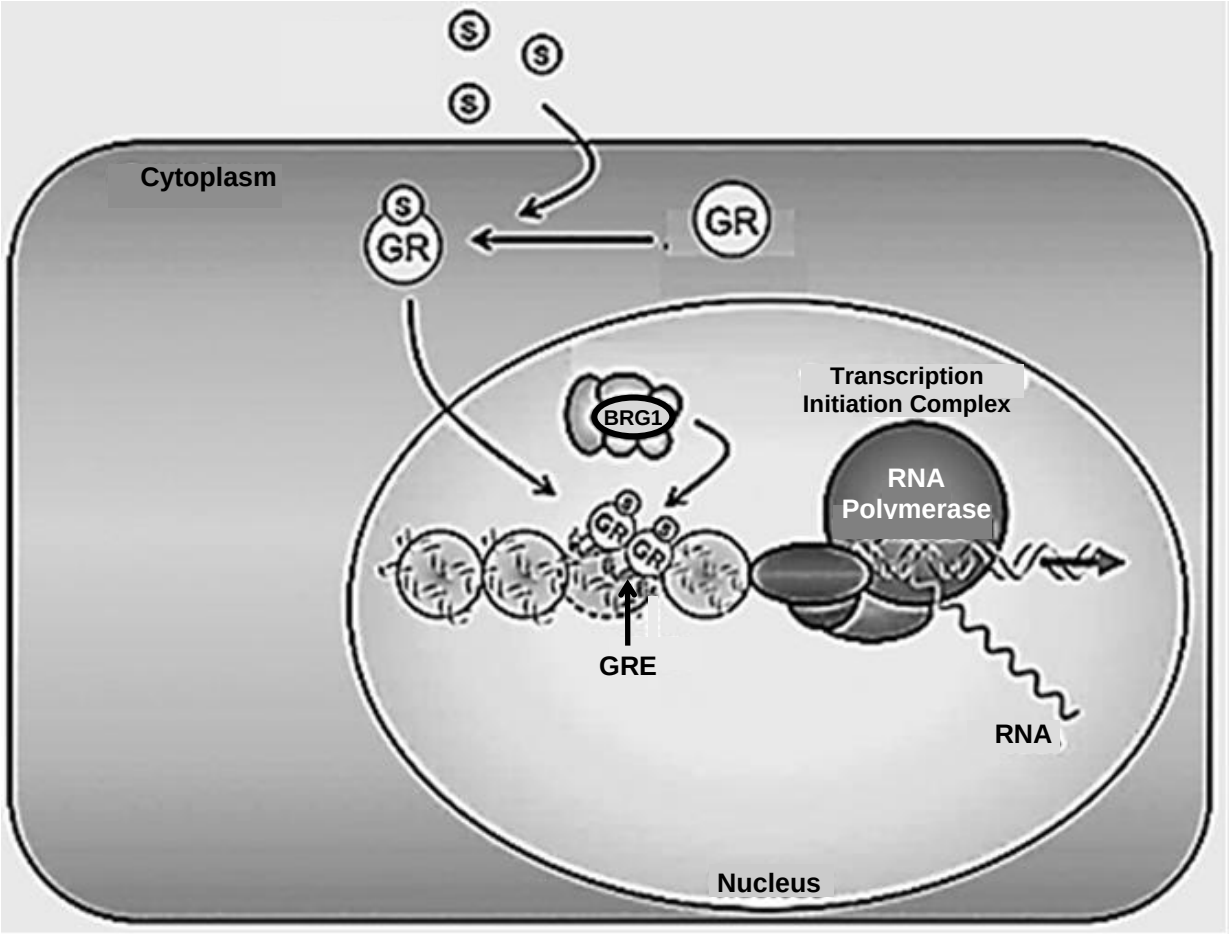


**Fig. 4.1**

For Examiner's Use

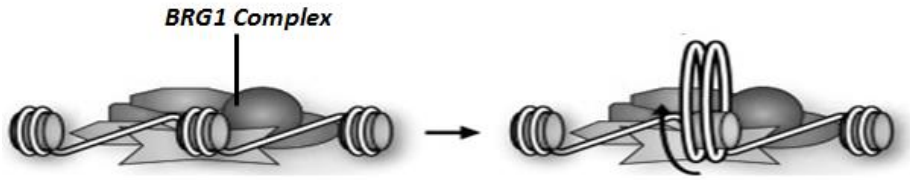


**Fig. 4.2**

**(a)** Explain how the steroid hormone is able to enter the cell. [1]

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**(b)** **GR**s are known to have highly conserved regions which are structurally important for its function.

Describe 2 structural features of **GR** which allows it to carry out its role. [4]

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**(c)** **(i)** With reference to the information provided, describe the effect of the presence of **S** on gene expression. [3]

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**(ii)** Briefly describe one other mechanism that may bring about a similar effect on gene expression as described in **(c)(i)** [1]

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**(d)** Function and activity of **GR**s are known to be affected by different post-translational modifications.

Suggest one post-translational modification and its effect on the activity of **GR**s. [1]

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[Total : 10]

**5** A researcher was investigating the inheritance of 3 gene loci in mice – coat colour, skin colour, and tail shape.

**(a)** In the first set of experiments, a pure breeding female mouse with agouti coat and fair skin was crossed with a pure breeding male mouse with albino coat and dark skin. All the $F_1$ offspring had agouti coat and dark skin. One of the male $F_1$ mouse was then testcrossed with a female mouse, and the result of the testcross was recorded in **Table 5.1**.

**Table 5.1**

| Phenotype | Male | Female |
|---|---|---|
| Agouti coat, fair skin | 18 | 20 |
| Agouti coat, dark skin | 7 | 6 |
| Albino coat, fair skin | 6 | 7 |
| Albino coat, dark skin | 18 | 18 |

**(i)** Describe the inheritance of coat colour and skin colour in mice. [2]

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**(ii)** Draw a genetic diagram to explain the results of the testcross. Use appropriate symbols to represent coat colour and skin colour. [5]

**(b)** The researcher then looked into the trait of tail shape separately, and derived the following pedigree as shown in **Fig. 5.1**. Normal tails are denoted by shaded symbols, whereas bent tails are denoted by unshaded symbols.

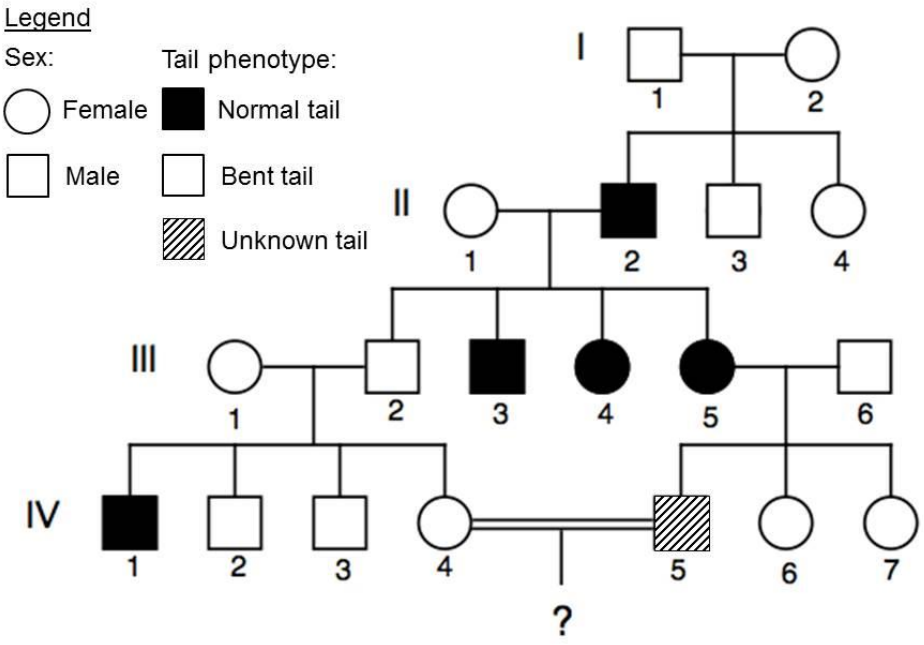


**Fig. 5.1**

From the results, the researcher concluded that gene for tail shape lies on the X chromosome.

**(i)** What is the probability of a cross between **IV-4** and **IV-5** (the phenotype of **IV-5** is unknown) producing a female mouse with normal tail. [1]

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**(ii)** Explain your answer in **(b)(i)**. [2]

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[Total : 10]

For Examiner's Use

**6(a)** **Fig. 6.1** shows a series of aerobic and anaerobic reactions.

Each ○ represents a carbon.

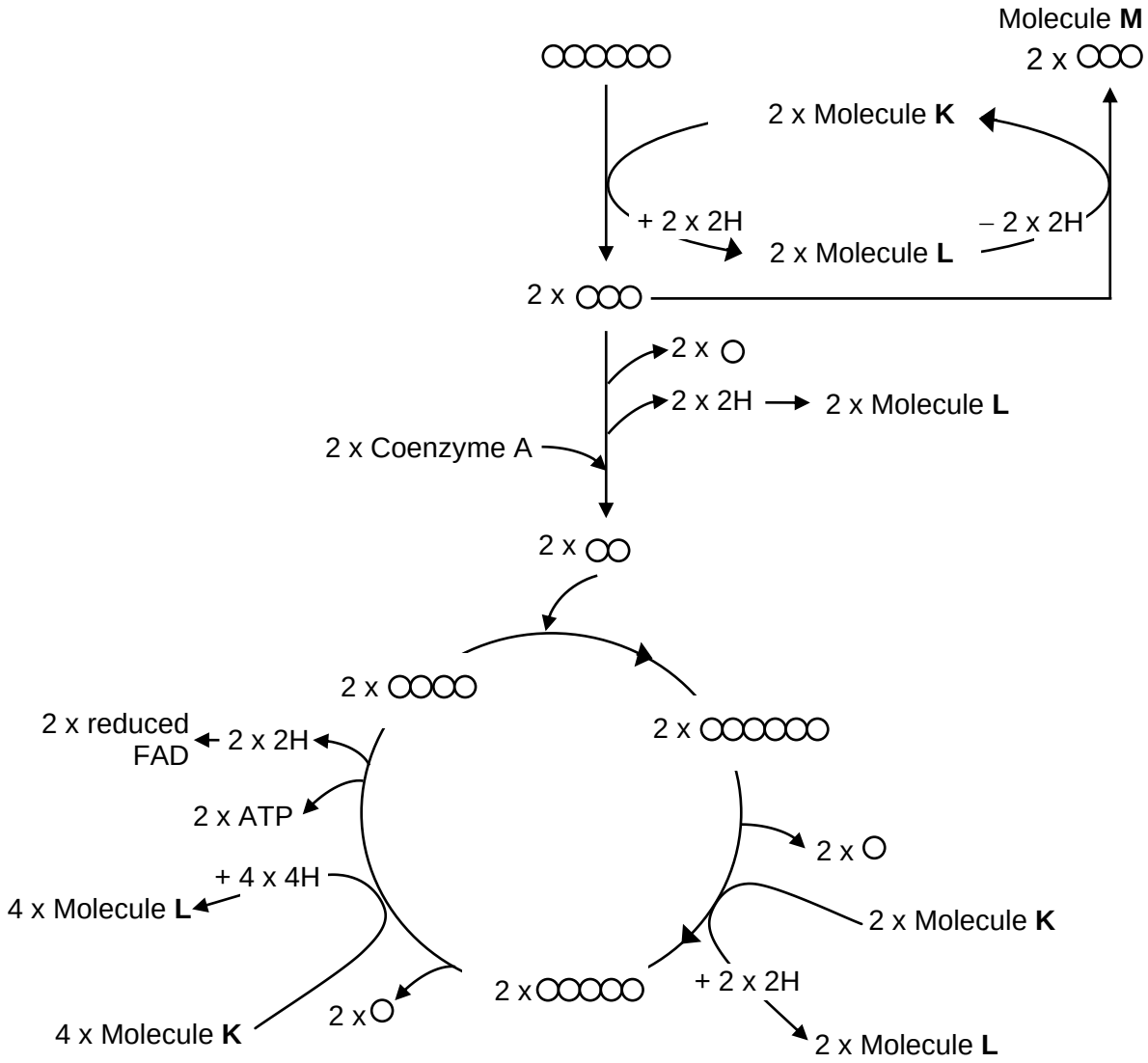


**Fig. 6.1**

**Fig. 6.2** shows an electron micrograph of a mitochondrion.

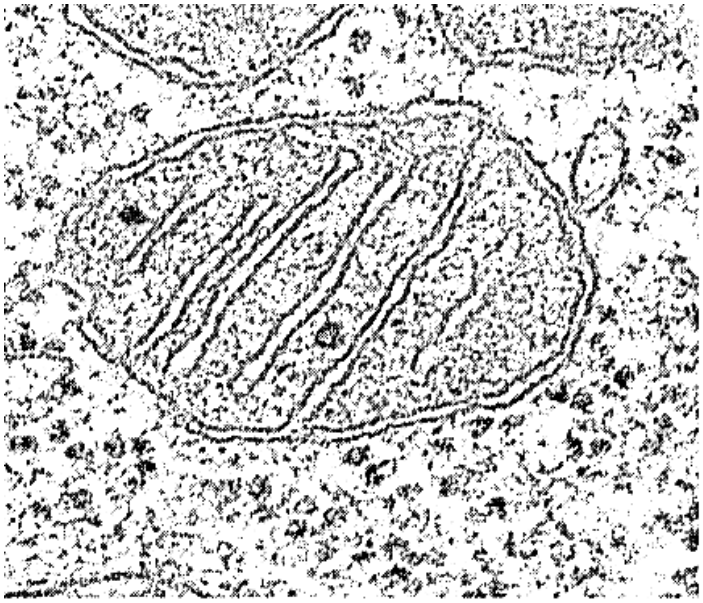

**Fig. 6.2**

With reference to **Fig. 6.1**,

**(i)** Using an '**X**', mark a point on **Fig. 6.2** clearly, showing where Molecule **M** is produced. [1]

**(ii)** Name Molecule **L**. [1]

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**(iii)** In aerobic conditions, explain how Molecule **L** is converted to Molecule **K**. [2]

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**(iv)** The mitochondrion has two major compartments. Suggest the significance of compartmentalisation within the mitochondrion. [1]

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**(b)** **Fig. 6.3** shows the absorption spectrum of one type of photosynthetic pigment from a plant and the rate of photosynthesis of the plant in different colours of light.

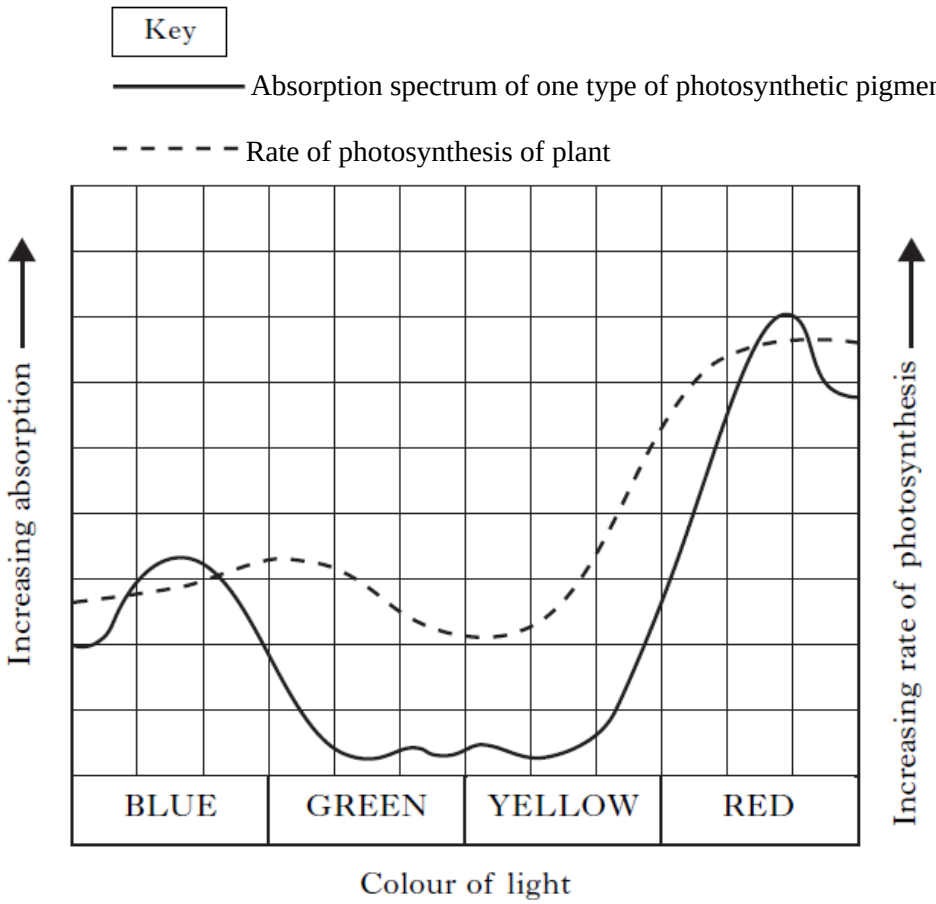


**Fig. 6.3**

**(i)** Leaves of this plant contain more than one type of photosynthetic pigment. Use evidence from the graph to justify this statement. [1]

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**(ii)** Plants typically have several photosynthetic pigments. Describe the role of accessory pigments in photophosphorylation. [1]

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*Spirogyra* is a photosynthetic green alga which grows as a long strand of cells. A strand of *Spirogyra* was placed into water containing aerobic bacteria. Different parts of the strand were exposed to different colours of light. After a period of time, the bacteria had moved into the positions shown in **Fig. 6.4**.

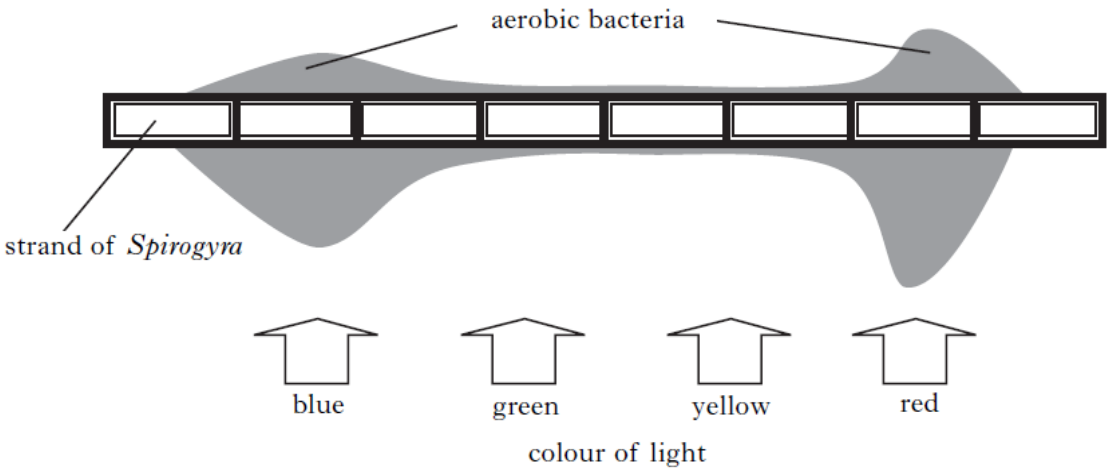


**Fig. 6.4**

**(c)** Explain the distribution of aerobic bacteria shown in the diagram. [2]

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[Total : 9]

*For Examiner's Use*

**7** A study was carried out to measure the concentrations of glucose and insulin in the blood. The results are summarised in **Fig. 7.1**.

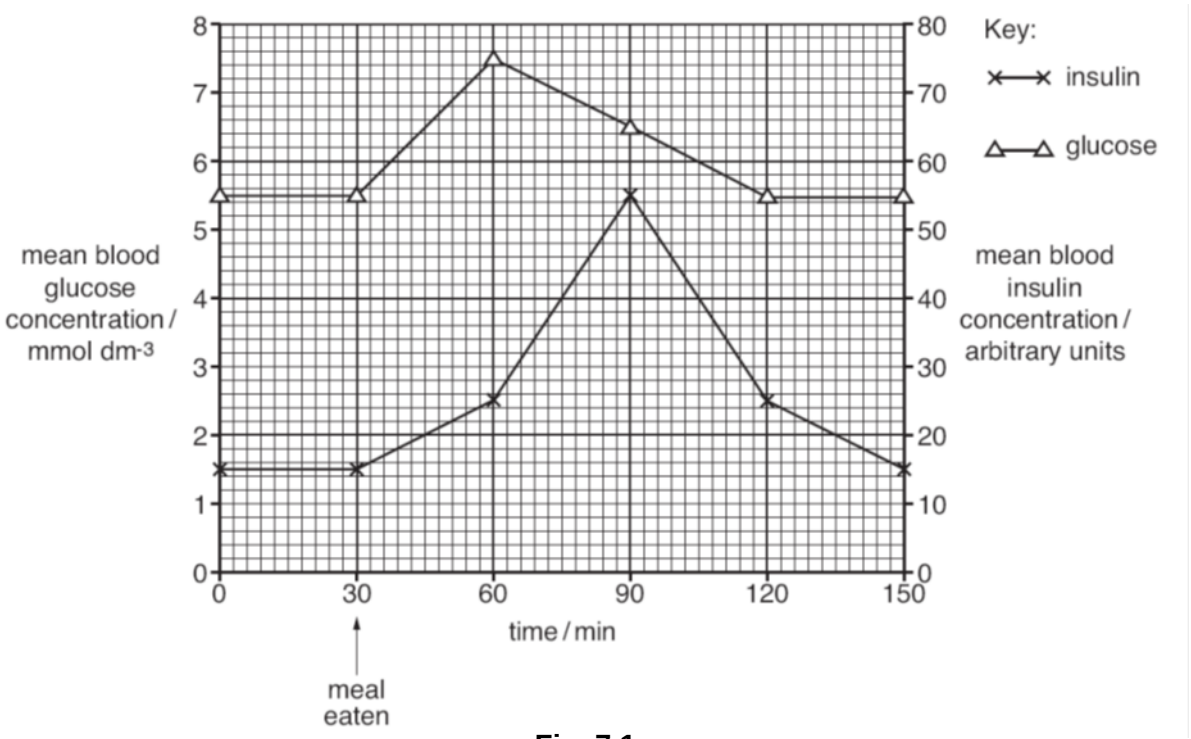


**Fig. 7.1**

**(a)** Explain the relationship between the concentration of glucose and the concentration of insulin shown in **Fig. 7.1** after the meal. [3]

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**(b)** The signal transduction pathway in **Fig. 7.2** is initiated by the binding of the growth factor (GF) to the receptor tyrosine kinase (RTK). This pathway controls the fundamental cellular processes such as growth, proliferation and differentiation.

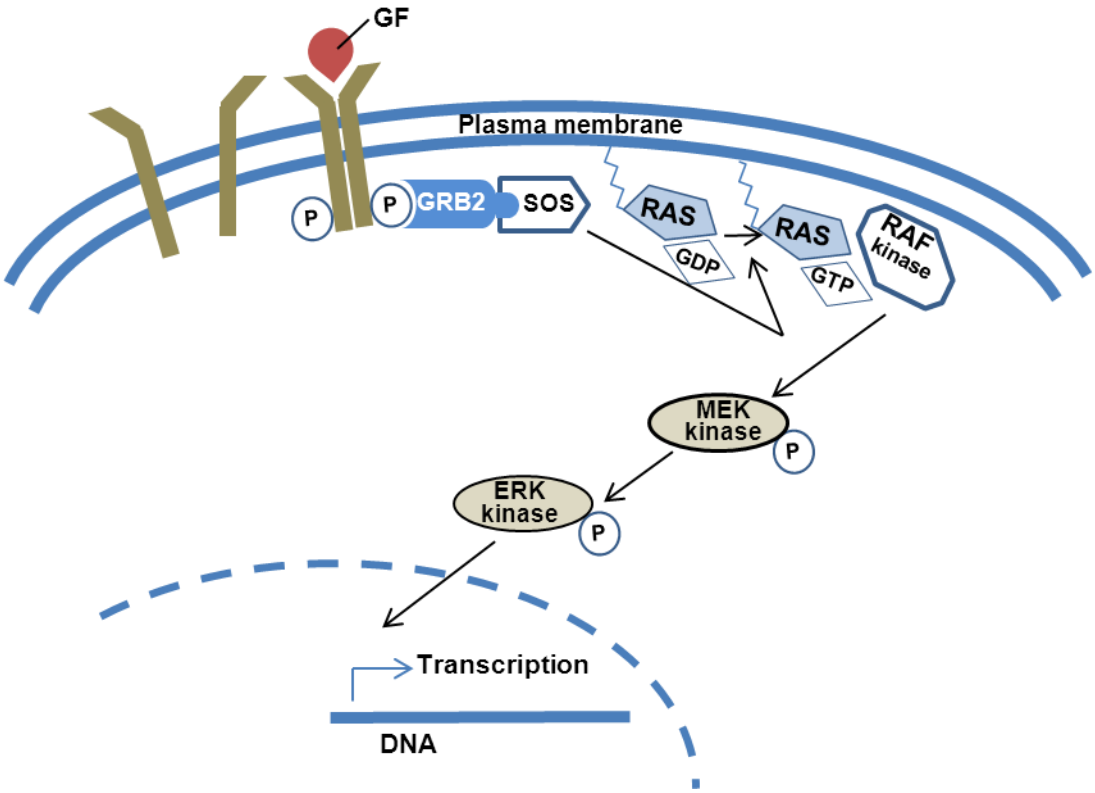


**Fig. 7.2**

With reference to **Fig. 7.2**,

**(i)** describe how Ras, a G protein, is activated; [4]

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For Examiner's Use

**(ii)** explain one significance of the series of events that occurs after the activation of Ras protein. [2]

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[Total : 9]

**8** Penguins are a group of aquatic, flightless birds living almost exclusively in the Southern Hemisphere. There are 17 species of penguins and they are all found in the South Pole including the continents indicated in **Fig. 8.1** below. Penguins are well adapted to the cold polar climate and feed on fish, krill, squid and any other forms of sea-life that they can catch underwater. Interestingly penguins do not exist in the North Pole.

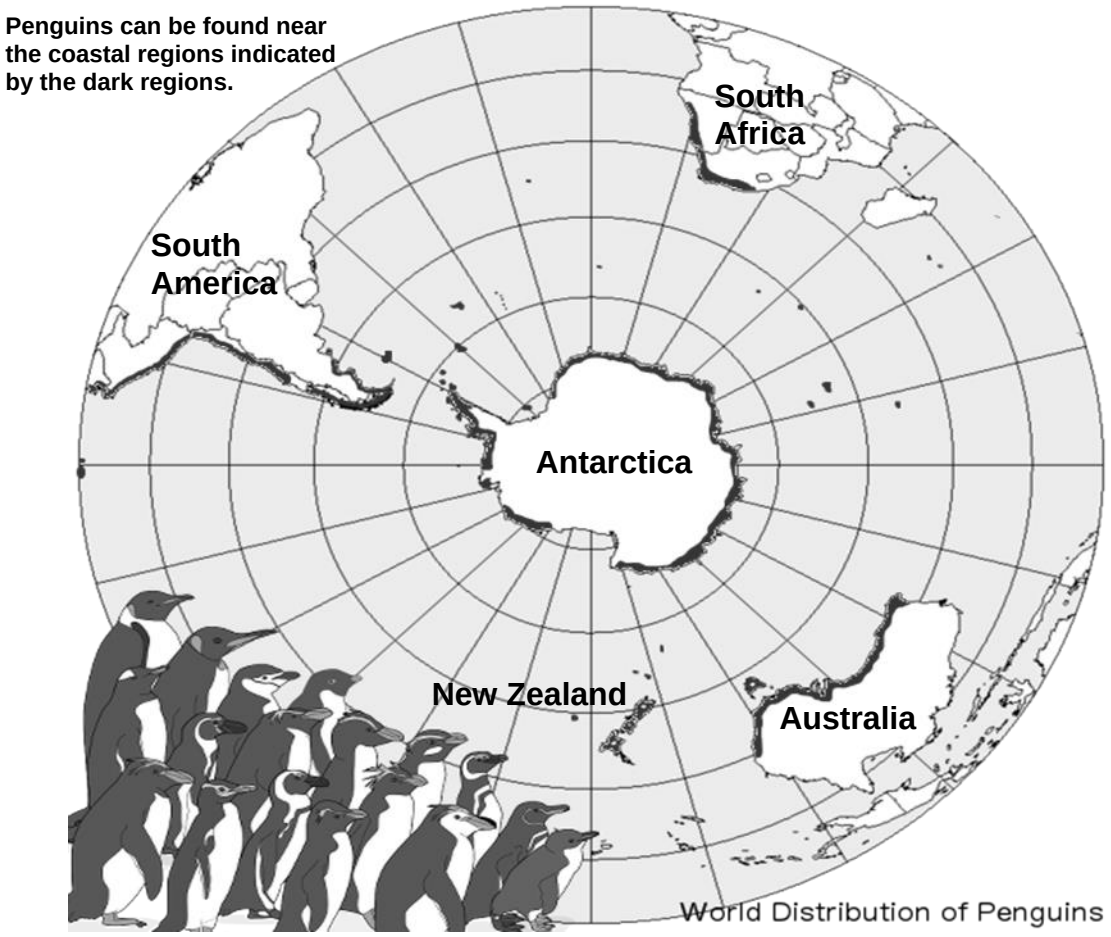


**Fig. 8.1**

The oldest known fossil penguin species lived some 62 million years ago in the region of the supercontinent that eventually formed New Zealand. The map of that time is shown in **Fig. 8.2**. The shapes of the modern continents and their names are superimposed over the supercontinent of that time.

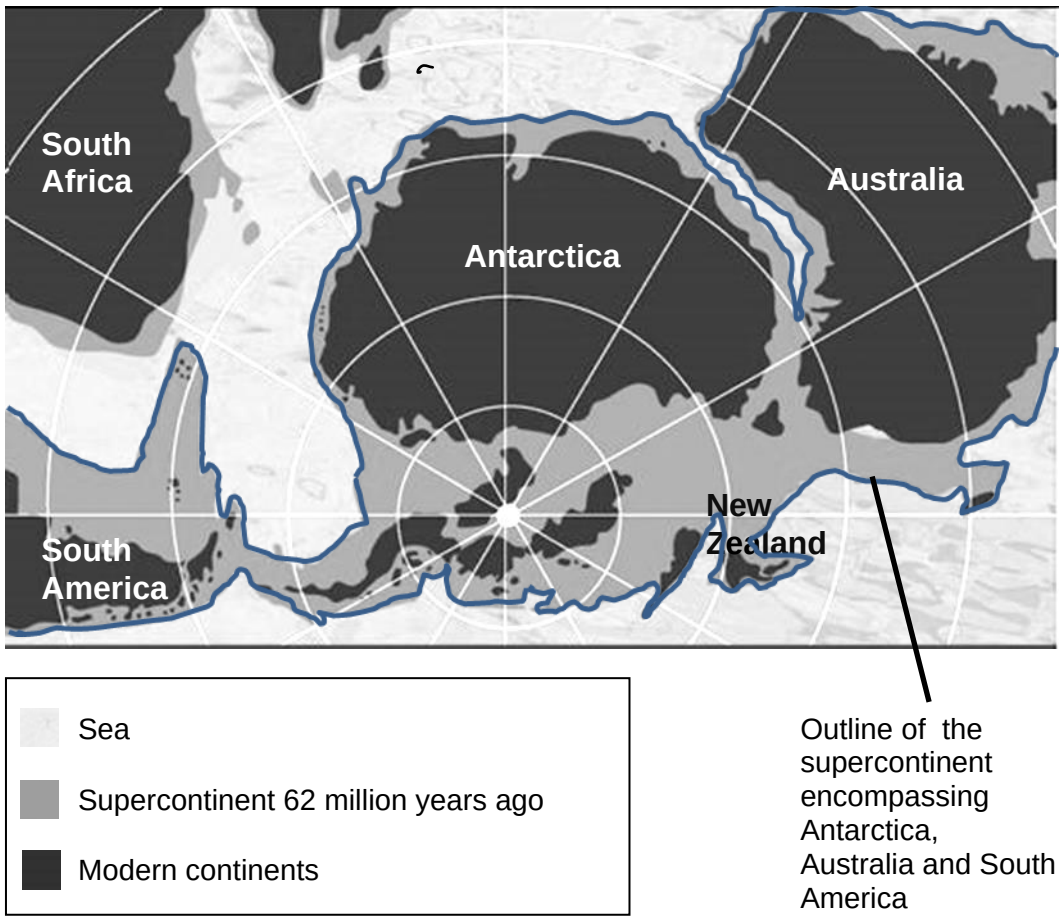


**Fig. 8.2**

**(a)** **(i)** Using all the information provided, explain how the biogeography of 17 existing penguin species supports Darwin's theory of evolution. [4]

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**(ii)** Suggest why there are no penguins in the North pole? [1]

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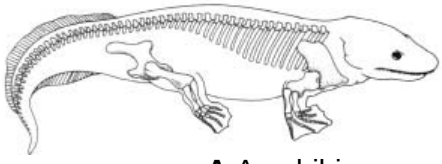
When Darwin proposed his theory of evolution by natural selection, one of the most important types of evidence he used to support the idea was fossil records.

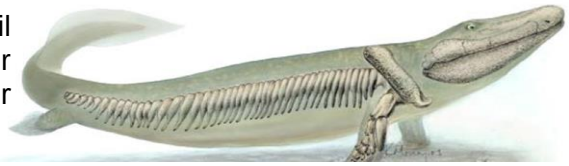
One important evolutionary change is from fish to amphibians, the first air breathing, four-legged animals. Until 20 years ago almost no fossils had been found that were intermediate between the two. Critics of evolution referred to a 'missing link'. However scientists predicted that such intermediates would eventually be found.

Several such fossils have now been found, exactly as predicted. **Fig. 8.3** shows some of these intermediate forms in order of age, with the oldest at the bottom.

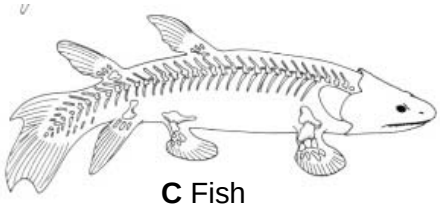


**A** Amphibian

No fossil evidence for Tiktaalik's rear



**B** Tiktaalik



**C** Fish

**Fig. 8.3**

**(b)** **(i)** Use Darwin's theory of natural selection to explain the process by which the four-legged amphibian, **A**, may have evolved, over about 20 million years, from the fish-like creature, **C**, in the swampy conditions of that time. [4]

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**(ii)** Tiktaalik was only found in 2004 and aroused great interest. Explain the significance of this 'missing link'. [2]

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[Total : 11]

*For Examiner's Use*

## Section B
## Answer EITHER 9 OR 10.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**9** **(a)** Explain why the population is the smallest unit that can evolve. [5]

**(b)** Explain the ways in which islands favour the formation of new species. [7]

**(c)** Describe and explain how genetic variation may be preserved in a population. [8]

**10** **(a)** Compare glycosidic bonds in carbohydrates with peptide bonds in protein. [5]

**(b)** Using a named example, relate the structure of a fibrous protein to its functions. [7]

**(c)** Explain how primary, secondary and tertiary structures of a protein affect the functions of a proteinaceous enzyme [8]

**-- END OF PAPER --**