RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME									
CENTRE NUMBER	S					INDEX NUMBER				

H2 BIOLOGY **9648/02**

Paper 2 Core Paper **15 Sep 2016**

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions in the spaces provided on the question paper.

Section B
Answer any **one** question on the answer paper provided.
Circle the question attempted on the cover page.

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.

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	
Section A	
1	**/ 10**
2	**/ 10**
3	**/ 9**
4	**/ 10**
5	**/ 10**
6	**/ 11**
7	**/ 10**
8	**/ 10**
Section B	
9 or 10*	**/ 20**
Total	**/ 100**

This Question Paper consists of **23** printed pages.

Section A (80 marks)

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

1 **Fig. 1.1** shows electronmicrographs of a zebrafish cell undergoing mitotic cell division.

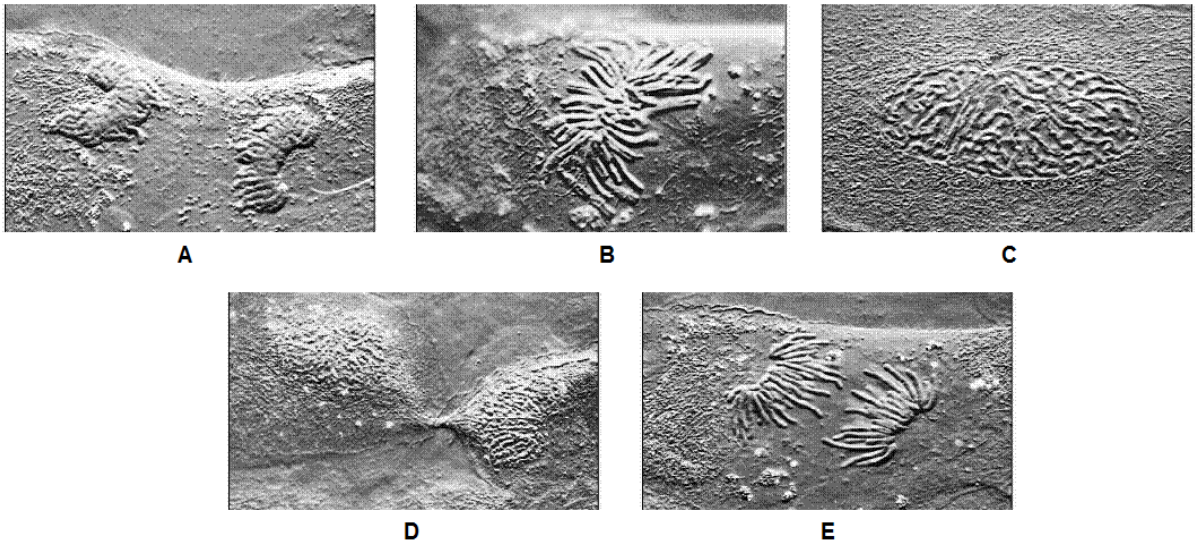

Fig. 1.1

(a) Explain the significance of mitosis to the development of zebrafish. [2]

(b) **(i)** Identify stage **A**. [1]

(ii) With reference to **Fig. 1.1**, describe two visible features that support the identification in **1(b)(i)**. [2]

(iii) Explain the significance of stage **D** to cell division. [2]

(c) Explain why sister chromatids are genetically identical. [3]

[Total: 10]

2 Human Immunodeficiency Virus (HIV) is a retrovirus which infects immune cells expressing CD4 receptor on its cell surface membrane.

(a) Explain the term *retrovirus*. [2]

In 2012, the United States Food and Drug Administration (FDA) approved the OraQuick In-Home HIV Test, which is the first test kit which can be bought at pharmacies.

The test kit relies on the presence of antibodies against gp120 in blood. Antibodies are produced by immune cells in response to exposure to foreign particles. If an individual had been infected by HIV for at least a month, there is a low probability of a false-negative result, whereby the kit incorrectly reports a negative result.

Fig 2.1 shows the changes in concentration of HIV RNA and antibodies against gp120 in the blood stream after HIV infection.

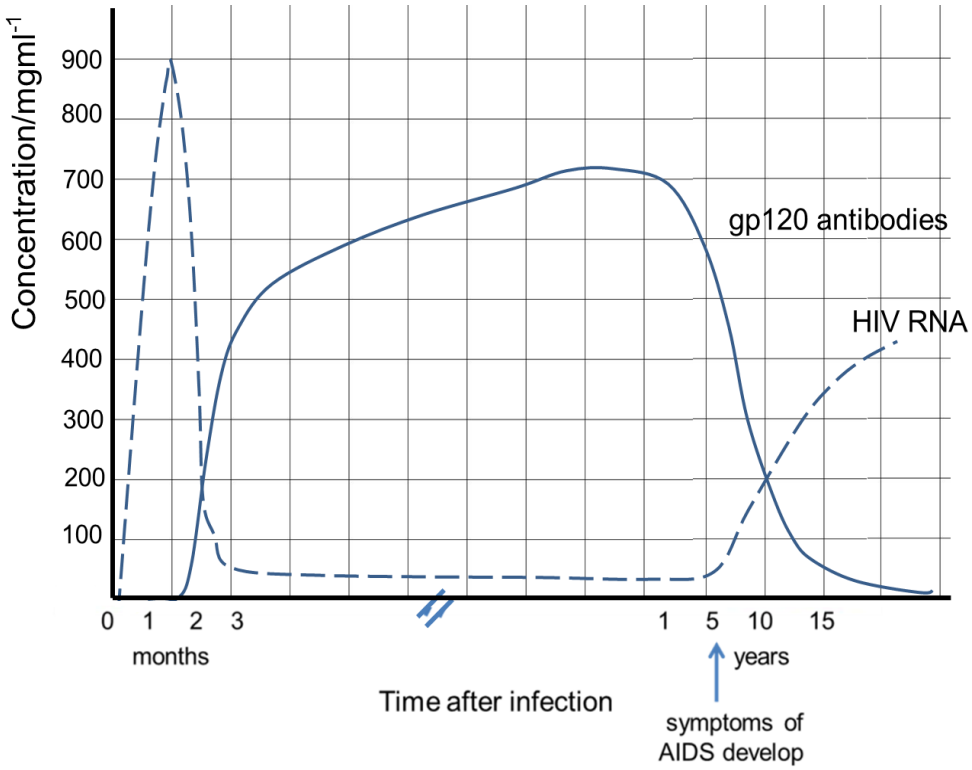

Fig 2.1

Adapted from Hunt, 2016, Virology, Microbiology and Immunology On-line.

http://www.microbiologybook.org/lecture/hiv3.htm

(b) With reference to **Fig 2.1**,

(i) describe how the concentration of gp120 antibodies in blood changes in relation to the concentration of HIV RNA in the first 3 months after infection; [2]

(ii) explain how HIV RNA concentration increases in the first month after infection; [1]

(iii) explain why presence of gp120 antibodies is used as a basis for the detection of HIV infection. [2]

Enveloped viruses like HIV leave the host cell via budding, but T4 bacteriophages use a different mechanism for release.

(c) Explain why release of HIV differs from the release of bacteriophages. [3]

[Total: 10]

Part I

3 An *in-vitro* transcription system allows a DNA segment from yeast to be successfully transcribed under the control of a eukaryotic promoter. Transcription of this DNA segment occurs when purified components (RNA polymerase II and general transcription factors) are added.

However, this *in-vitro* transcription system using purified components occurs at low efficiency, as compared to that using nuclear extract. This suggests that an important gene regulatory protein present in the nuclear extract is missing from the purified components.

(a) (i) State a possible identity of the missing gene regulatory protein. [1]

(ii) Describe how the gene regulatory protein identified in **3(a)(i)** could result in higher efficiency of transcription. [1]

To search for the DNA sequence to which this gene regulatory protein binds, five segments located upstream of the transcription start site (+1) is each deleted in various experimental set-ups. The TATA box is located 15 base-pairs upstream of the transcription start site. Each deleted template is incubated with a non-deleted template, which serves as a control. The four deletion sites are shown in **Fig. 3.1**.

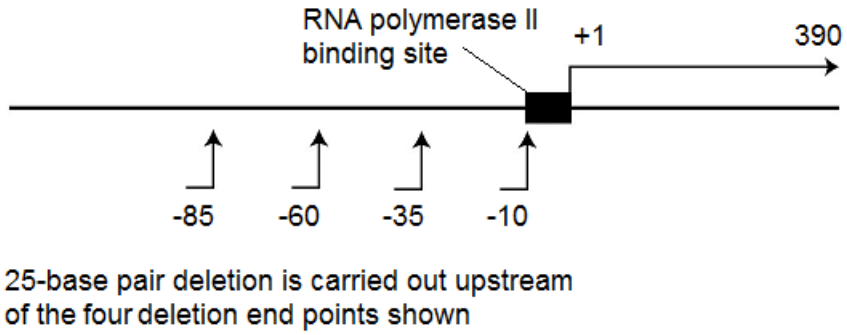

Fig. 3.1

The transcription activity of these deletions in the transcription system using nuclear extract is shown in **Table 3.1**.

Table 3.1

Deletion end point	-10	-35	-60	-85
Activity in deleted template / a.u.	0	10	24	23
Activity in non-deleted template / a.u.	23	24	24	23

(b) With reference to **Fig. 3.1** and **Table 3.1**,

(i) describe the extent of change in transcription activity caused by different deletions. [2]

(ii) Suggest a reason for the transcription activity at -10 deletion end point. [2]

(iii) Deduce the binding site of the gene regulatory protein. [1]

Part II

In a separate experiment that studies the effect of starvation on yeast cells, it was observed that the cells upregulate the synthesis of GCN4 protein when deprived of purine. The α subunit of eukaryotic initiation factor 2 (eIF2) was found to be phosphorylated, and this leads to increased translation of mRNA encoding GCN4.

(c) **(i)** State the level of gene regulation employed for GCN4. [1]

(ii) Explain why this level of gene regulation may be advantageous to the survival of yeast cells. [1]

[Total: 9]

4 In pigeon, pigment distribution is controlled by two genes. In the presence of the dominant allele for spread pigmentation, no pattern is observed. **Fig 4.1** shows the appearance of pigeon with spread and patterned pigmentation. In a farm, pure-breeding pigeon with spread pigmentation and pure-breeding pigeon with barless pattern pigmentation were bred, all the pigeons in the F_1 generation have spread pigmentation.

Patterned pigmentation

Spread pigmentation

Fig. 4.1

When the F_1 pigeons were allowed to interbreed, the phenotype and number of offspring were recorded.

Pigeon with spread pigmentation	86
Pigeon with barless pattern pigmentation	8
Pigeon with bar pattern pigmentation	23

Use the following symbols to represent the alleles:

S – Spread **s** – no spread **B** – Bar pattern **b** – barless

(a) Draw a genetic diagram in the space below to explain the F_1 cross. [4]

(b) State the name for this type of interaction between gene loci. [1]

(c) Explain how different genotypes give rise to spread pigmentation in pigeons. [2]

The χ^2 equation and distribution table are shown below. The calculated χ^2 value for the cross is 4.3.

$$\chi^2 = \Sigma \frac{(O-E)^2}{E}$$

Table 4.1

Degree 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

(d) Using the calculated χ^2 value and **Table 4.1,** explain what conclusion can be drawn from the recorded data. [2]

(e) Suggest one reason why the conclusion in **4(d)** may not be valid. [1]

[Total: 10]

5 **Fig 5.1A** and **Fig 5.1B** are electron micrographs of the same plant cell.

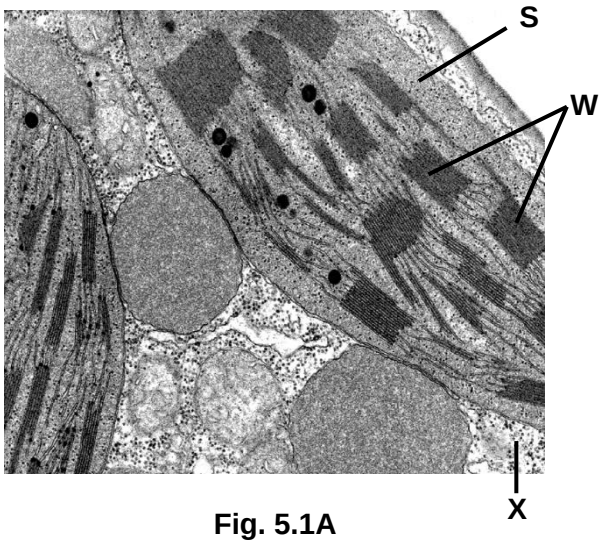

Fig. 5.1A

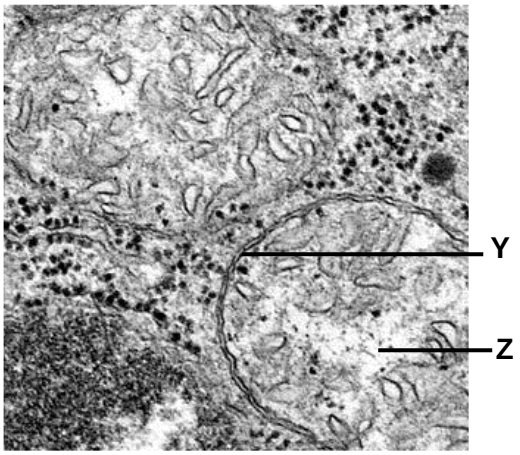

Fig. 5.1B

Source: http://botit.botany.wisc.edu/Resources/Botany/

(a) State in which labelled component(s) will there be the highest concentration of [2]

RuBP carboxylase _____

ATP synthase _____

pyruvate decarboxylase _____

acetyl-coA _____

The optimum pH for the activity of RuBP carboxylase is pH8.

(b) Explain why the illumination of chloroplasts leads to optimum pH condition for RuBP carboxylase. [3]

_____

_____

_____

_____

_____

_____

(c) A herbicide binds irreversibly to RuBP carboxylase. Explain how this herbicide kills weeds. [3]

(d) Describe two ways in which the reactions of the Calvin cycle differs from Krebs cycle. [2]

[Total: 10]

6 ATP-binding cassette (ABC) transporters are transmembrane proteins that utilises the energy from ATP binding and hydrolysis to transport various substances across cellular membranes. They exhibit the ability to switch between two states upon hydrolysis of ATP. Most eukaryotic ABC transporters function as part of the efflux system, removing substances out of cells.

The human ABC-B1 transporter is responsible for multiple drug resistance observed in patients, rendering a variety of structurally unrelated drugs ineffective in treatment of diseases. **Fig. 6.1** shows the structure of a ABC-B1 transporter.

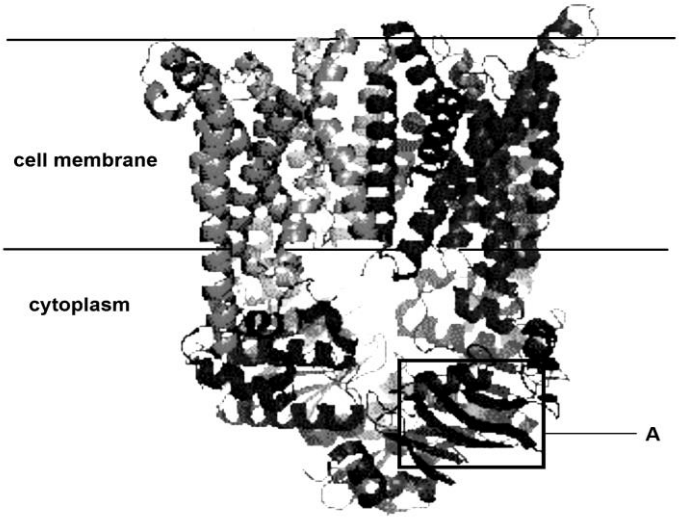

Fig. 6.1

(a) **(i)** Describe how structure **A** is folded. [2]

(ii) Explain how ABC-B1 transporter is held in the cell membrane. [3]

Digoxin is drug derived from the leaves of a plant, and is used in treatment of congestive heart failure. Digoxin is polar in nature, thus is retained in cells by the cell membrane to exert its effect. However, patients are observed to develop resistance to digoxin due to the increased number of ABC-B1 transporters removing digoxin out of cells.

(b) Explain how ABC-B1 transporter removes digoxin out of cells. [3]

To overcome the drug-resistance, patients may be prescribed with verapamil, an inhibitor of ABC-B1 transporter.

In a clinical trial to determine the effectiveness of verapamil, fluorescent-tagged verapamil was administered to a patient with overexpression of ABC-B1 transporter proteins.

At various time intervals, the relative fluorescence of the target cells was measured and the results are recorded in **Table 6.1**.

Table 6.1

Time after administration of verapamil / h	Relative fluorescence / rfu
20	15.7
40	9.8
60	5.4
80	2.3

(c) **(i)** State a feature of verapamil that allows for it to carry out its function. [1]

(ii) Describe the results shown in **Table 6.1**. Suggest a reason for the observation. [2]

[Total: 11]

7 **(a)** Explain the role of calcium ions in synaptic transmission. [3]

GABA is a neurotransmitter which inhibits the production of action potential. **Fig. 7.1** and **Fig. 7.2** shows how the release of GABA from a pre-synaptic neurone affects the membrane potential of a post-synaptic membrane.

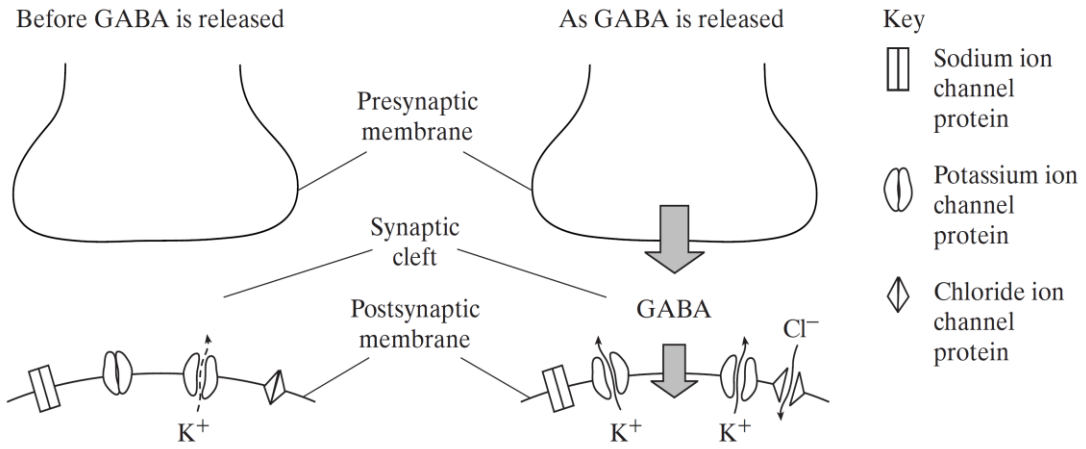

Fig. 7.1

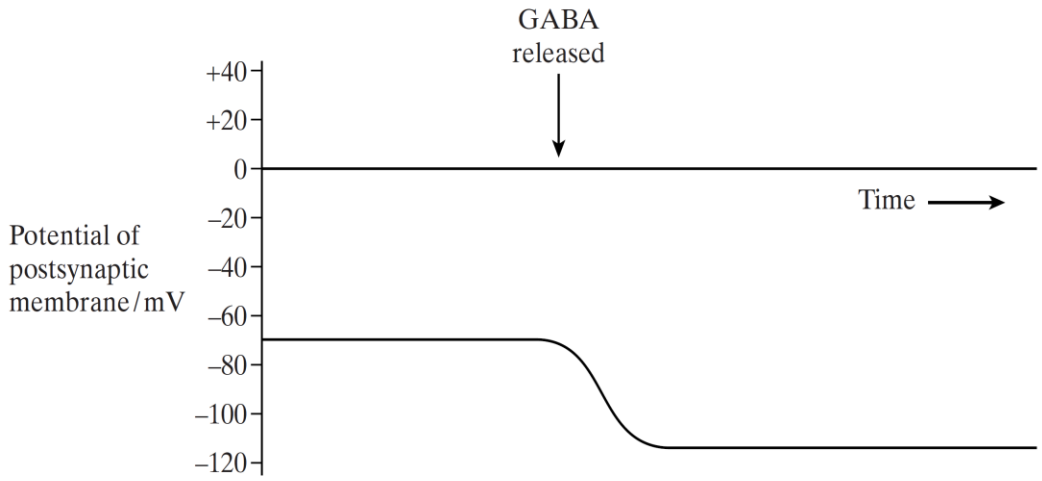

Fig. 7.2

(b) When the post-synaptic membrane is stimulated by acetylcholine, an action potential is less likely to occur if GABA is released. Explain why. [3]

Epilepsy is a neuronal disorder which causes recurrent, unprovoked seizures. This may result when there is increased neuronal activity in the brain.

One form of epilepsy is due to insufficient GABA. GABA is broken down on the post-synaptic membrane by the enzyme transaminase. Vigabatrin is a new drug used to treat this form of epilepsy. The drug has a similar molecular structure to GABA.

(c) Suggest how Vigabatrin may be effective in treating this form of epilepsy. [2]

Fig. 7.3 shows the relationship between diameter of the axon and the speed of conduction of nerve impulses in the myelinated axons of a cat.

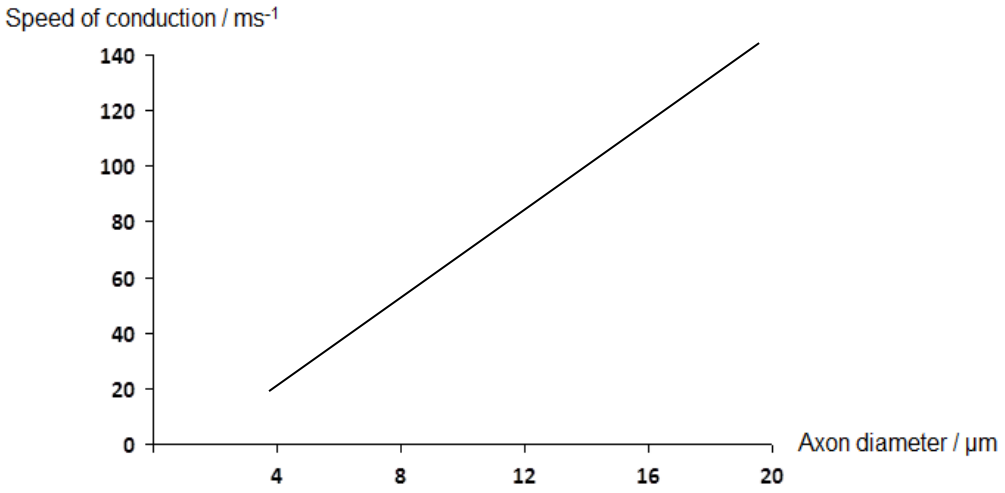

Fig. 7.3

(d) As the diameter of the axon increases, the length of myelination between the nodes increases.

Explain how this resulted in the speed of conduction shown in **Fig 7.3**. [2]

[Total: 10]

8 The Canary Islands form an archipelago of seven volcanic islands just west of the African continent. Lanzarote is the oldest island of about 24.0 million years old in the island chain while Hierro is the youngest island of about 0.8 million years old. The distribution of three species of lizards of the genus *Gallotia* in the Canary Islands is investigated.

Fig 8.1 shows the distribution of the lizard species in these islands and the maximum age of the island. **Fig 8.2** shows the relative body size of the lizards found in these islands.

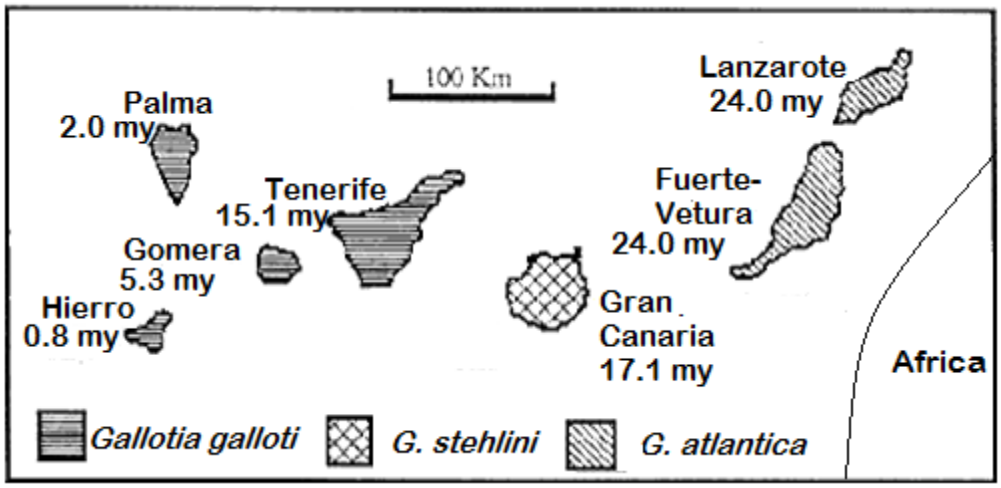

Fig. 8.1

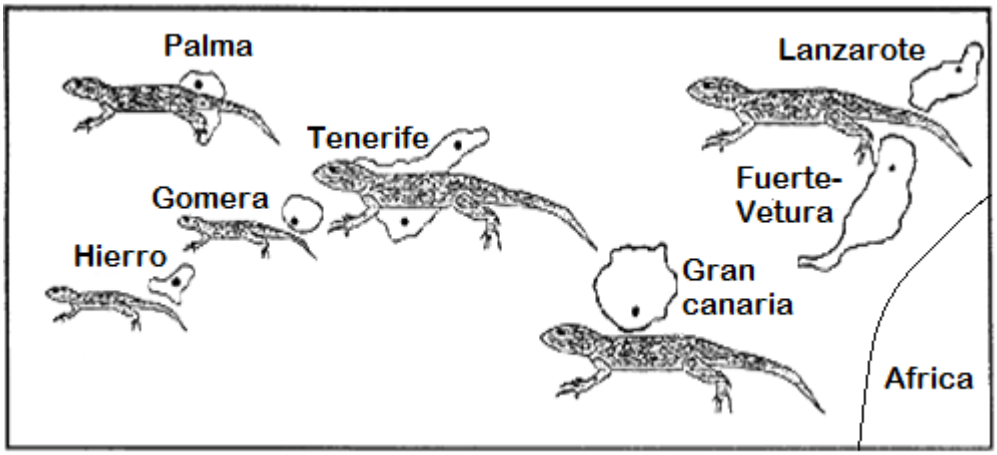

Fig. 8.2

(a) **(i)** Explain how the distinct phenotypic differences between the lizard populations may have arisen. [5]

(ii) Suggest why the lizard populations on Tenerife, Palma, Gomera and Hierro are classified as a single species. [1]

The cytochrome b genes from the different populations of lizards are sequenced. The cytochrome b gene sequences were then compared and the difference in number of base pairs is summarised in **Table 8.1**.

Table 8.1

G. stehlini	*G. stehlini*						
G. atlantica	36	*G. atlantica*					
G. galloti Palma	41	25	*G. galloti* Palma				
G. galloti N. Tenerife	40	23	8	*G. galloti* N. Tenerife			
G. galloti S. Tenerife	40	19	10	6	*G. galloti* S. Tenerife		
G. galloti Gomera	45	24	19	19	15	*G. galloti* Gomera	
G. galloti Hierro	49	28	19	21	17	4	*G. galloti* Hierro

N. Tenerife - North of Tenerife island
S. Tenerife - South of Tenerife island

G. galloti Palma — species name / location

(b) Describe how these changes in DNA sequences and dates of island formation can help taxonomist to classify the lizards on the Canary Islands accurately. [4]

[Total: 10]

Section B (20 marks)

Answer **one** question.

Write your answers on the separate answer paper 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 sections **(a)**, **(b)** etc., as indicated in the question.

A **NIL** return is necessary if you have not attempted this section.

9. **(a)** Outline how the structure of membranes in the endomembrane system facilitates their function. [10]

(b) Distinguish between tropocollagen and amylose. [10]

[Total: 20]

10. **(a)** Using a named example, describe how mutation may result in a disease and its associated symptoms. [11]

(b) Explain the role of nuclear membrane in regulating eukaryotic gene expression. [9]

[Total: 20]