Origins of life

Question Paper

Level	Pre U
Subject	Biology
Exam Board	Cambridge International Examinations
Topic	The origin and evolution of life
Sub Topic	Origins of life
Booklet	Question Paper

Time Allowed: **136 minutes**

Score: **/113**

Percentage: **/100**

Part - A

1 **(a)** About one third of the injuries to racehorses involve tendon damage. In 2006, bone marrow stem cells were taken from injured racehorses and cultured so that they divided many times by mitosis. Each horse's cells were then injected into its damaged tendons. 80 % of the treated horses returned to racing, compared with 30 % of those treated conventionally.

(i) Adult stem cells such as these are described as multipotent.

Explain what is meant by the term *multipotent*.

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(ii) Describe how the rate of mitosis is controlled.

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(iii) Suggest how it is possible that bone marrow stem cells could differentiate into the range of cell types needed for repairing injuries.

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A biopsy was taken from the muscle of a healthy racehorse.

Fig. 4.1 shows drawings made from three different transverse sections of the muscle as seen with a transmission electron microscope.

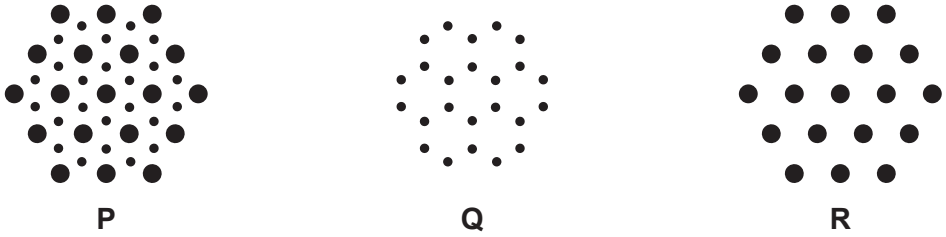

Fig. 4.1

(b) With reference to Fig. 4.1, explain the differences between sections **P**, **Q** and **R**. You may draw a diagram to illustrate your answer.

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(c) The coordination of muscular contraction is essential in successful racehorses. Muscle weakness in racehorses may sometimes be related to a deficiency of calcium.

Outline the roles of calcium ions in the coordination of muscle contraction.

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[Total: 16]

2 In the 1950s, chemists thought that the Earth's atmosphere, before the existence of life, was highly reducing. In 1953, Stanley Miller, working under the supervision of Harold Urey at the University of Chicago, published the results of an experiment that showed that organic molecules could have formed in such an atmosphere.

A diagram of Miller's apparatus is shown in Fig. 1.1.

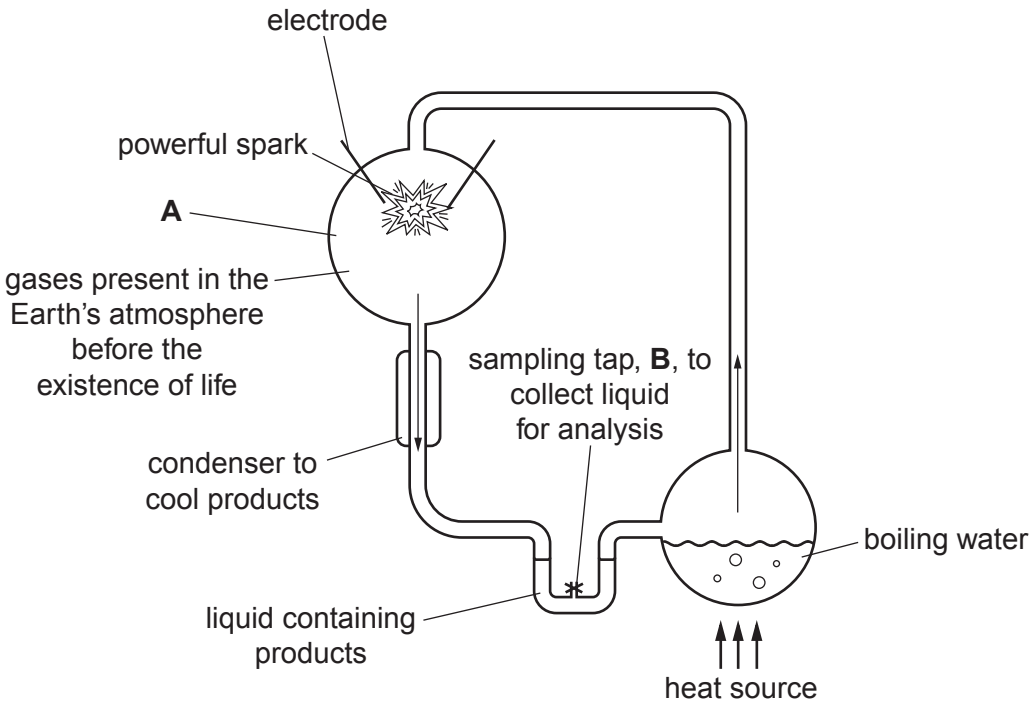

Fig. 1.1

(a) (i) Name three gases, apart from water vapour, that were present in this early atmosphere and that Miller put into chamber **A**.

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(ii) Name two different types of organic molecule that Miller collected at **B**.

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2. ..... [2]

(iii) State the role of the powerful spark in Miller's apparatus.

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(iv) Explain why liquid water had to be present for life to originate on Earth.

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Fig. 1.2 shows a time line for the early history of the Earth.

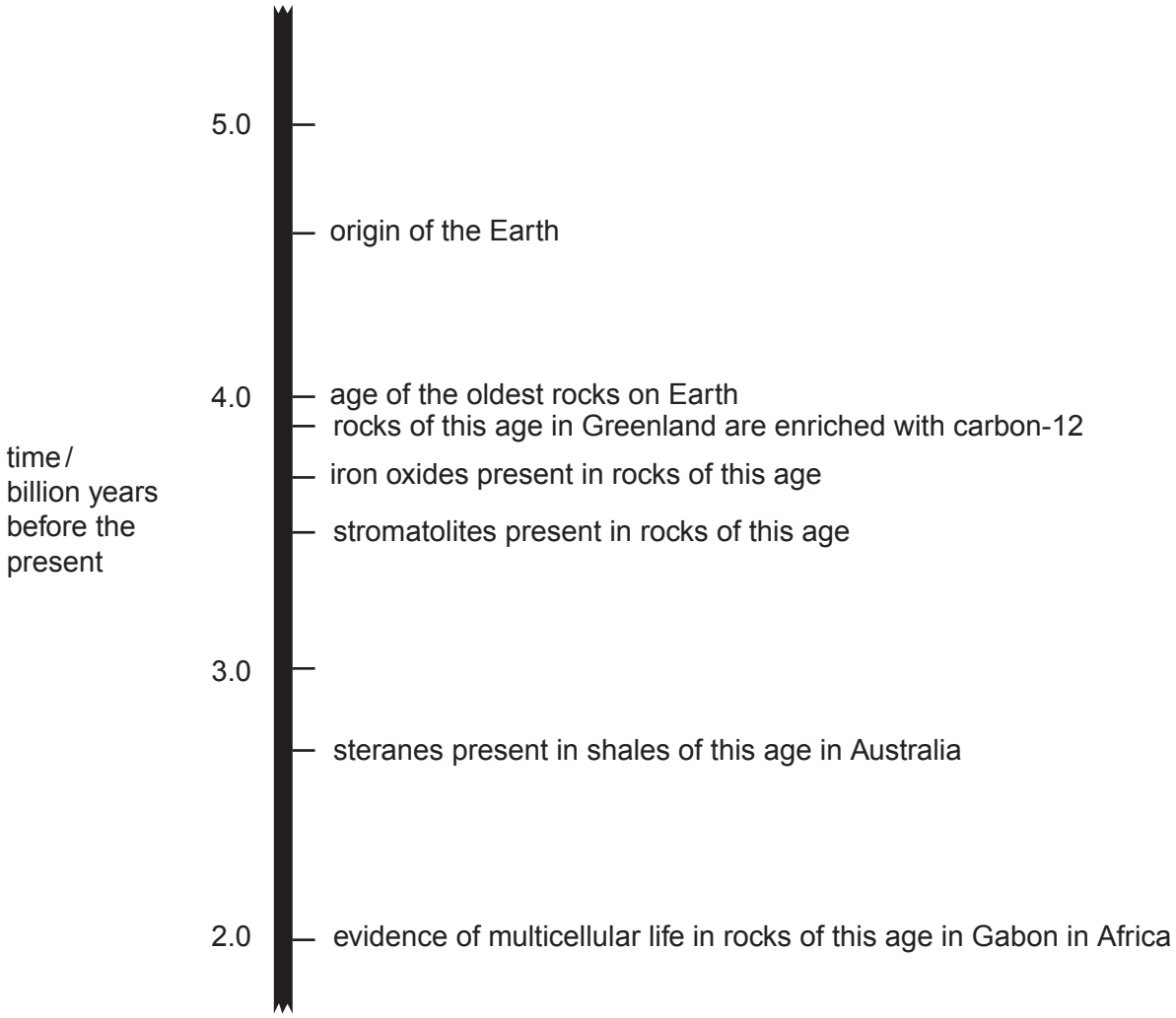

Fig. 1.2

(b) State the significance of,

(i) the enrichment with carbon-12 of rocks that are 3.9 billion years old

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(ii) the presence of stromatolites in rocks that are 3.5 billion years old

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(iii) presence of steranes in shales that are 2.7 billion years old.

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(c) Life may have originated around hydrothermal vents. Today, communities associated with these vents are rich in chemoautotrophic bacteria.

Describe briefly the nutrition of chemoautotrophic bacteria.

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[Total: 16]

Part - B

3 'There is no evolutionary advantage in being multicellular'.

Discuss this view.

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[Total f: 30]

Adapted to survive in a harsh habitat

The Shetland Islands lie in the Atlantic 100 km north of mainland Scotland (Fig. 5.1). The Keen of Hamar (Fig. 5.2) is a rocky headland in northern Shetland where there are large areas of stony ground known as debris, which are almost bare of vegetation.

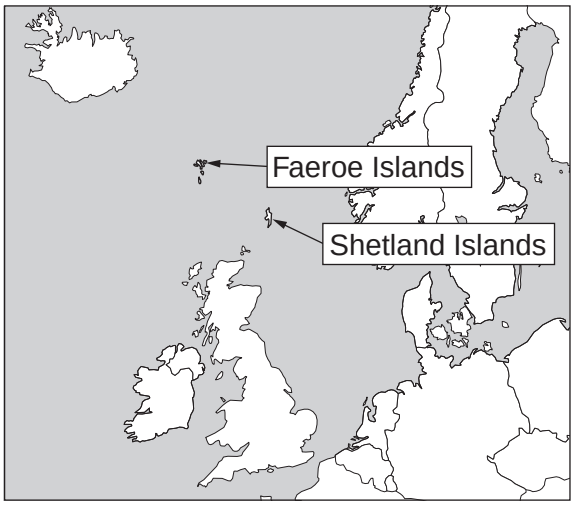

Fig. 5.1

Fig. 5.2

Fig. 5.3

Fig. 5.4

Shetland, the most northerly part of the UK, is only 400 km south of the Arctic Circle but it has an oceanic, rather than an arctic, climate with mild winters (relatively little frost) and cool summers. Most of Shetland is not bare like the Keen but is covered in vegetation, mainly grassland, heather moor and peat bog. The Keen is a Site of Special Scientific Interest (SSSI). The debris, with its shallow, nutrient-deficient, sandy, freely-draining soil may look bare, but quite a number of plant species grow amongst the small stones on the surface. Of particular scientific interest is the Shetland mouse-ear, *Cerastium nigrescens* (Fig. 5.3 and Fig. 5.4), which is almost entirely confined to the Keen debris. This species is believed to have always been restricted to this area, where it evolved in response to local environmental conditions.

The Shetland mouse-ear almost certainly evolved from the Arctic mouse-ear, *Cerastium arcticum*, a species which remains widespread on bare stony soil in the northern parts of Scandinavia, Russia, Siberia and North America. The nearest population of Arctic mouse-ear to the Keen is 200 km to the north-west, in the Faeroe Islands (Fig. 5.1).

At the end of the last Ice Age, the Arctic mouse-ear is thought to have been widespread not only on Shetland, but also further south, growing on stony ground left bare by melting ice. Over the next few thousand years vegetation, such as forest, heath or grassland, spread north to cover most of the land. The Keen debris habitat was one of the exceptions to this and it remained bare despite no longer having an arctic climate. It has probably changed little in 10 000 years.

4 Between 1981 and 1982, hay was spread across small areas of the Keen debris to feed cattle in winter. When the animals congregated to eat the hay, they deposited dung on the debris and this represented a significant input of nutrients, such as phosphate (eutrophication). The effects of this were studied by marking out a number of areas of 4 m × 4 m = 16 m^2 with permanent markers (Fig. 6.1). Each area was divided into 16 quadrats of 1 m × 1 m. The density of Shetland mouse-ear plants was determined in each of these quadrats and the mean density calculated. The mean percentage cover of all plant species was estimated using the point quadrat method (Fig. 6.2).

Fig. 6.1

Fig. 6.2

Data were recorded on several occasions, before and after the eutrophication event, and the results from the sampled quadrats are presented in Table 6.1.

Table 6.1

	Year						
	1977	1980	1985	1987	1991	1993	2006
mean density of Shetland mouse-ear / plants per m^2	5		1				
mean percentage total plant cover	10	11	68	71	56	67	76

(a) (i) As well as sampling the permanently marked quadrats, the researchers also used randomly placed quadrats across the whole of the Keen.

Suggest why they did this.

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(ii) Describe **and** explain the patterns shown by the data in Table 6.1.

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(iii) Suggest a suitable control for this study.

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(b) Suggest the priorities for the conservation of the Shetland mouse-ear.

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[Total: 11]

5 Discuss the issues raised for biologists if life were shown to exist, or to have existed in the past, on Mars.

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6 Complex multicellular organisms, such as flowering plants and vertebrates, have evolved, in addition to transport at a cellular scale, a variety of strategies for longer distance transport within their bodies. Describe these different strategies and their relative merits. Do not include transport into and out of cells.

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