GCE Biology

S21-A400U20-1

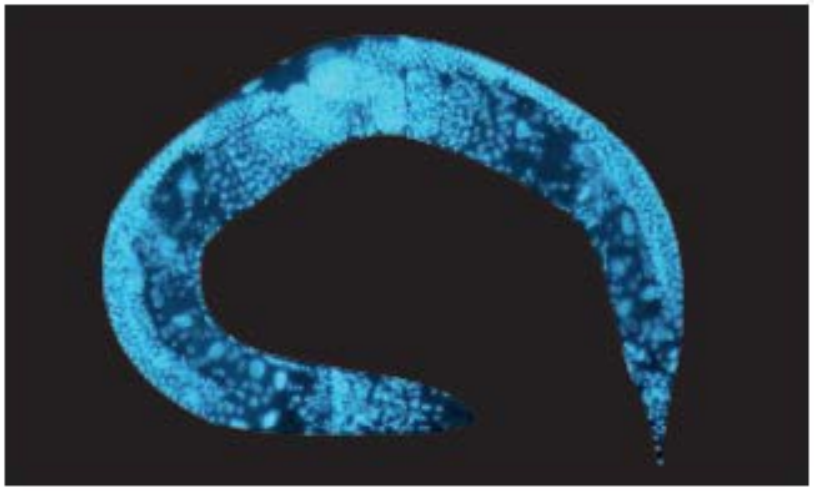
Assessment Resource 17

Continuity of Life Resource H

1. *Caenorhabditis elegans* is a species of nematode worm found living free in soil. The adult worms are approximately 1 mm in length and contain only 959 body (somatic) cells.

Image 1.1 shows an adult *C. elegans* stained to show the position of the nuclei of each cell. The photograph was taken using a fluorescence microscope.

Image 1.1



(a) (i) When examining an organism using a microscope, describe **one** advantage and **one** disadvantage of staining the organism. [2]

Advantage

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Disadvantage

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(ii) Suggest the power of the objective lens used to take the photograph shown in **image** 1.1 [1]

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(b) Most *C. elegans* adults are hermaphrodite, possessing both male and female reproductive systems. The majority of zygotes are produced by self-fertilisation. This is followed by repeated cell divisions to produce the body cells.

(i) State the types of cell division involved in the production of the body cells and the gametes. [1]

body cells .....

gametes .....

(ii) Estimate the **minimum number** of cell divisions needed to produce the 959 body cells (somatic cells) found in the adult hermaphrodite nematode. [1]

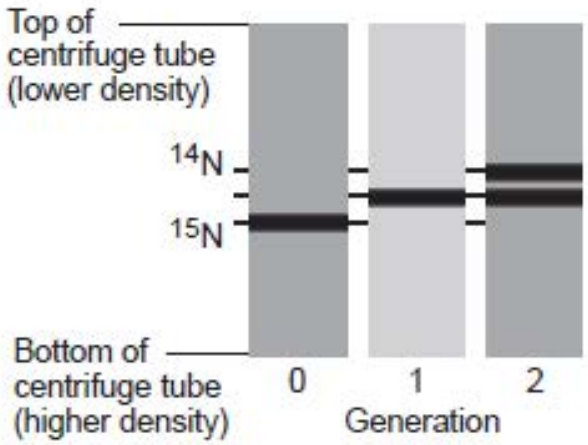
Minimum number of cell divisions = ...

(c) During the cell cycle, DNA has been shown to replicate semi-conservatively. Meselson and Stahl were the first scientists to prove this experimentally.

In their experiments they cultured bacteria with a nitrogen source containing only ^{15}N – a heavy isotope of nitrogen. The bacteria were then transferred to a culture medium containing ^{14}N – a light isotope of nitrogen. Samples of DNA were extracted from the initial ^{15}N culture (generation 0) and after one and two replications with ^{14}N (generations 1 and 2). The DNA from each sample was spun in an ultracentrifuge.

Image 1.2 shows the positions of the DNA in each sample.

Image 1.2



Explain how the evidence shown in **image** 1.2 proved that DNA replicates semi-conservatively. [2]

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(d) Mutations that occur during DNA replication can be responsible for causing cells to become cancerous by activating genes that prevent the control of cell division. However, cancerous growths (tumours) are very rare in *C. elegans* and only occur in the germ line cells.

(i) Name the genes that when mutated can trigger uncontrolled cell division and state the term used to describe the chemicals that can cause these mutations. [2]

Genes .....

Term used to describe chemicals .....

(ii) Nearly all of the body cells are fully differentiated but some remain as stem cells and are responsible for the production of gametes.
Conclude why tumours only develop in the germ line cells and very rarely in the body cells of this organism. [2]

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(e) Scientists have used *C. elegans* to study epigenetic effects on genes that are involved in the control of the cell cycle and how these effects could trigger the development of cancers.

One form of epigenetic modification involves the methylation of cytosine bases in regions of genes that control the expression of that gene.

Explain how methylation could affect the quantity of a polypeptide produced, but not the structure of a polypeptide. [3]

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2. Many plants, especially those which have been selectively bred to produce food for humans are polyploid, with several complete sets of chromosomes. For example, wild strawberries, are $2n = 14$ but those grown commercially are octoploid, with eight sets of chromosomes.

(a) State how many chromosomes would be in the following cells during different stages of the life cycle of a commercially grown strawberry plant. [2]

a cell in the ovary wall .....

a pollen tube nucleus .....

a primary endosperm nucleus .....

Strawberries are often used as a source of DNA for extraction in a school laboratory. The following method was used to extract DNA from a strawberry.

1. Place a strawberry in a sealable plastic bag and crush.
2. Add 10 cm^3 of a mixture containing 1 cm^3 of detergent (pH 9), 0.1 g of salt and 10 cm^3 of water to the bag and mix thoroughly with the crushed strawberry.
3. Place the bag containing the strawberry mixture in a water bath at 60 °C for 15 minutes.
4. Cool the contents by placing the bag in a water bath of iced water.
5. Filter the mixture through a coffee filter paper into a clean beaker. Keep the filtrate.
6. Place 10 cm^3 of the filtrate in a boiling tube and add 2–3 drops of a protease enzyme and mix. Leave for 2 minutes.
7. Carefully pour ice-cold ethanol down the side of the tube to form a layer 1 cm deep on top of the filtrate. Let it stand for 3–4 minutes.
8. DNA precipitates into the ethanol. It should look cloudy. Using a glass rod, gently lift out some of the DNA.

(b) (i) Using **only** the information given, suggest why strawberries are often used as a source of DNA for extraction in a school setting. [1]

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(ii) Coffee filter paper has a pore size of approximately 20 µm. Suggest why coffee filter paper is used rather than Grade 1 laboratory filter paper with a pore size of 11 µm. [1]

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(iii) A protease is added to digest enzymes present in the cytoplasm of strawberry cells that could digest the DNA. Explain why you could not use **pepsin** as the protease when following this method. [2]

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(c) In medicine, DNA samples can be taken from a developing foetus as part of pre-natal testing for genetic disorders. The quantity of DNA extracted is very small.
Identify and describe a method that can be used to increase the quantity of DNA available for analysis. [3]

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One genetic disorder that can be detected through analysis of foetal DNA is beta thalassaemia. This disorder is caused by a mutation to the gene coding for the beta-globin chain of adult haemoglobin. To date the only possible cures that have been trialled are stem cell therapy and gene therapy.

(d) In 2008, a child was born from an embryo produced by *in vitro* fertilisation. Before implantation the embryo was screened to ensure that it did not carry the gene for beta thalassaemia. Following the birth of the child, stem cells from the baby's umbilical cord were saved and transplanted to his brother who suffered from beta thalassaemia. These replaced the stem cells in his brother's bone marrow and red blood cells were then produced that had normal haemoglobin.

(i) Suggest why the treated child should still receive genetic counselling in the future before trying to become a parent. [2]

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(ii) Suggest why there is opposition to producing one child specifically to treat a genetic disorder in another child. [1]

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(e) Gene therapy for beta thalassaemia has been trialled.
Suggest **one** advantage and **one** possible disadvantage of using a non-pathogenic virus as the vector for the beta-globin gene. [2]

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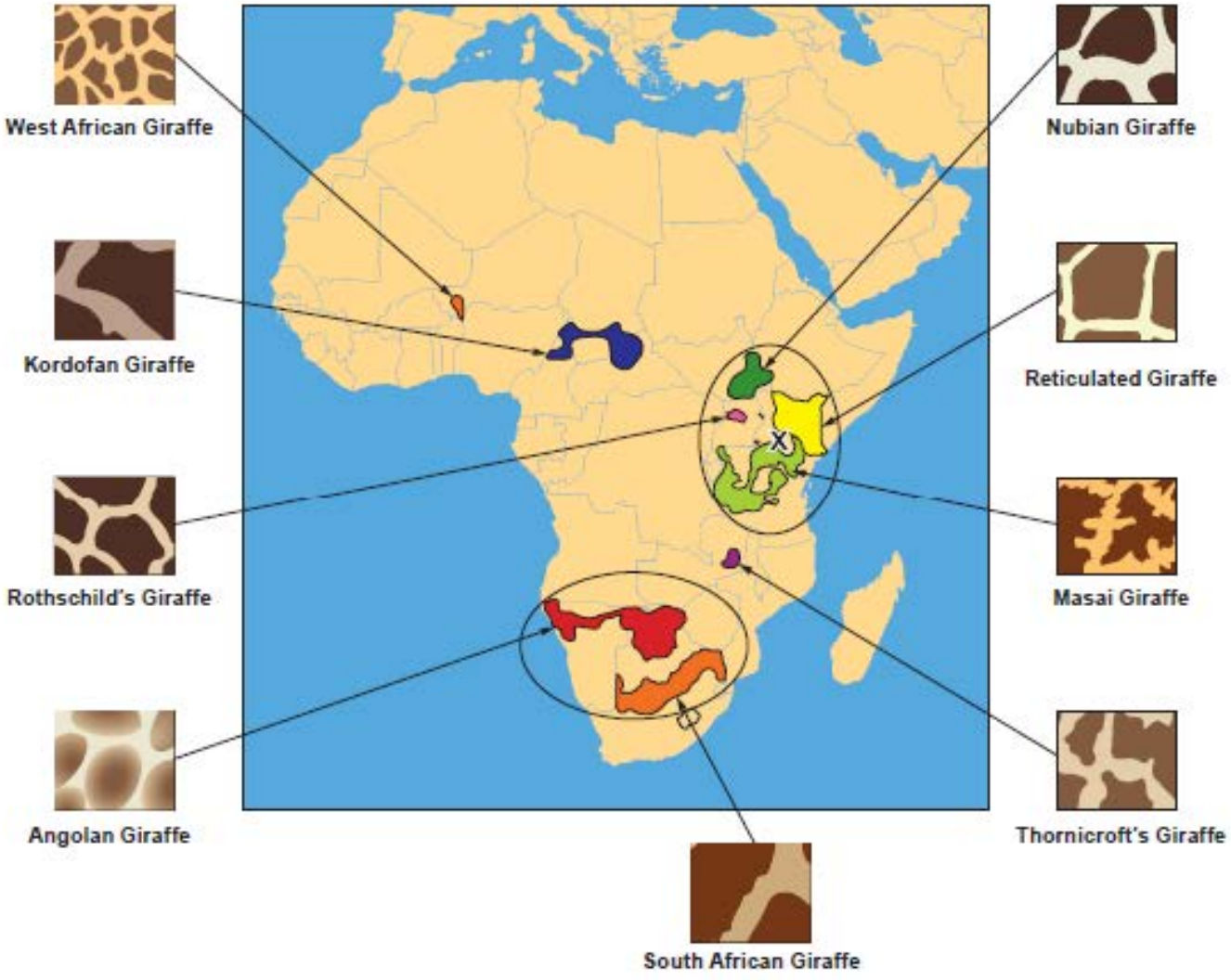
3. Today, there are an estimated 1500 giraffes held in captivity and approximately 90000 in the wild. There are several different coat patterns that are similar to each other but are different in colouration and size of coloured areas in different populations. Giraffes live in a range of habitats ranging from sandy scrubland to dense forest.

Currently, only a single species of giraffe, *G. camelopardalis*, is recognised, but studies suggest that there may be up to nine species of giraffe. **Image** 3.1 shows the current distribution of the proposed different species of giraffe together with their typical coat patterns.

Image 3.1



Giraffe populations are found in many parts of Africa. Some are now separated from other populations while others co-exist in the same parts of the continent (indicated by the oval shapes).

It has been suggested that different coat patterns evolved from a single ancestral form found in East Africa (marked **X** on the map). A number of different factors are believed to be responsible for the formation of the proposed different species of giraffe during the last million years.

Use the information provided and your own knowledge to explain how evolution could have resulted in the appearance of different coat patterns. Explain how **two** different forms of speciation may have resulted in the development of different species of this animal. [9 QER]

END OF PAPER