| Surname | Centre Number | Candidate Number |
|---|---|---|
| First name(s) | | 2 |

wjec cbac

# GCE A LEVEL

A400U20-1

O20-A400U20-1

eduqas
Part of WJEC

**FRIDAY, 16 OCTOBER 2020 – MORNING**

# BIOLOGY – A level component 2

## Continuity of Life

2 hours

| For Examiner's use only | | |
|---|---|---|
| **Question** | **Maximum Mark** | **Mark Awarded** |
| **1.** | **14** | |
| **2.** | **14** | |
| **3.** | **14** | |
| **4.** | **18** | |
| **5.** | **16** | |
| **6.** | **15** | |
| **7.** | **9** | |
| **Total** | **100** | |

A400U201
01

**ADDITIONAL MATERIALS**

In addition to this examination paper, you will need a calculator and a ruler.

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional pages at the back of the booklet, taking care to number the question(s) correctly.

**INFORMATION FOR CANDIDATES**

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

The assessment of the quality of extended response (QER) will take place in question **7**.

The quality of written communication will affect the awarding of marks.

OCT20A400U20101

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*Answer* **all** *questions.*

**1.** Gregor Mendel published his laws of heredity in 1866. He carried out breeding experiments using the garden pea, *Pisum sativum*. He investigated the inheritance of characteristics that had at least two distinct **forms** or **traits**. He developed varieties of peas that were **pure breeding** for the traits of each characteristic that he investigated. He determined that characteristics are inherited as '**units of inheritance**' and that while some units of inheritance always appear in the offspring produced from a cross, others did not.

*(a)* (i) State the term currently used in genetics to describe the **form** or **trait** of a characteristic. [1]

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(ii) Explain what is meant by the term **pure breeding**. [1]

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(iii) Mendel's '**units of inheritance**' are now known as alleles. Explain why some characteristics always appear in the offspring produced from a cross, while others do not. [2]

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Examiner only

Pea flowers are insect-pollinated and contain both female and male reproductive organs. In many of his experiments, Mendel prevented self-pollination and self-fertilisation by removing the male reproductive organs and cross-pollinating the flowers by hand. In other experiments he allowed plants to self-pollinate by preventing cross-pollination.

*(b)* (i) Name the male reproductive organs and explain how their removal would encourage cross-pollination. [2]

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(ii) Suggest how Mendel could have prevented cross-pollination. Explain your answer. [1]

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Examiner only

*(c)* In one experiment, Mendel crossed pure breeding pea plants which produced smooth, yellow peas with pure breeding plants that produced wrinkled, green peas. The $\mathbf{F_1}$ were allowed to self-fertilise. **Image 1.1** shows the $\mathbf{F_1}$ and $\mathbf{F_2}$ offspring produced in this experiment.

**Image 1.1**

**Parent traits:** smooth, yellow × wrinkled, green

$\mathbf{F_1}$ **trait** all smooth yellow

$\mathbf{F_2}$ **traits**

| | | Seed colour | | |
|---|---|---|---|---|
| | | **yellow** | **green** | **total** |
| **Seed shape** | **smooth** | 311 | 106 | 417 |
| | **wrinkled** | 101 | 33 | 134 |
| | **total** | 412 | 139 | 551 |

(i) Calculate the ratio of the following combinations of traits found in the $\mathbf{F_2}$ offspring. **Give each value to one decimal place**. [2]

| $\mathbf{F_2}$ **trait** | smooth yellow | | smooth green | | wrinkled yellow | | wrinkled green |
|---|---|---|---|---|---|---|---|
| $\mathbf{F_2}$ **ratio** | .................... | : | .................... | : | .................... | : | .................... |

(ii) Explain how these pure breeding parents produced the combinations of traits shown in the $\mathbf{F_2}$ offspring. [2]

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*(d)* In the early 1900s, further genetic crosses were carried out to investigate inheritance in the garden pea. They studied two characters, flower colour – purple or red, and the shape of pollen grains – long or round. They crossed plants that were pure breeding for purple flowers and long pollen grains with plants pure breeding for red flowers and round pollen grains. The $\mathbf{F_1}$ were allowed to self-fertilise to produce the $\mathbf{F_2}$ generation. The results of this cross are shown in **table 1.2**.

**Table 1.2**

| Characteristics | Number of offspring |
|---|---|
| purple flower, long pollen grains | 4 831 |
| purple flower, round pollen grains | 390 |
| red flower, long pollen grains | 393 |
| red flower, round pollen grains | 1 338 |

A400U201 05

(i) Suggest why this cross did not produce the same ratio of the combination of characters as found by Mendel in his experiment. [1]

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(ii) Using your knowledge of meiosis, explain how plants producing purple flowers and round pollen grains could have been produced in this cross. [2]

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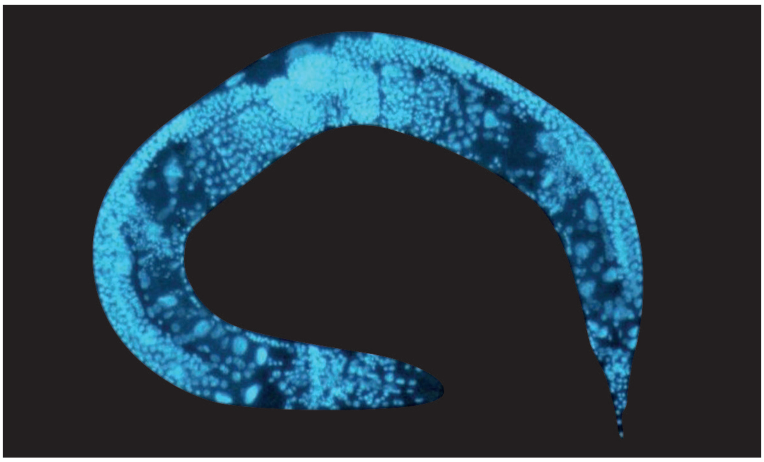
Turn over.

Examiner only

**2.** *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 2.1** 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 2.1**



*(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 2.1**. [1]

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Examiner only

*(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 = ........................................

A400U201 07

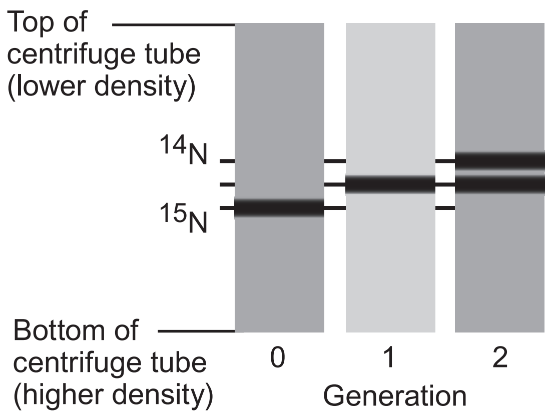
Examiner only

*(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 2.2** shows the positions of the DNA in each sample.

**Image 2.2**




Explain how the evidence shown in **image 2.2** proved that DNA replicates semi-conservatively. [2]

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Examiner only

(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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A400U201 09

(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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Examiner only

**3.** 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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Examiner only

(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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Examiner only

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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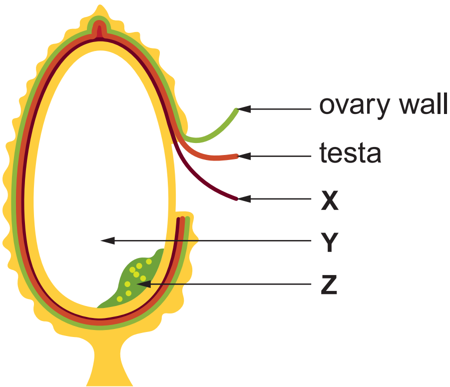
Examiner only

**4.** Rice, *Oryza sativa*, is a staple food crop for over half of the world's population. It provides most of the carbohydrate intake for people in many countries. **Image 4.1** shows the structure of a rice grain.

**Image 4.1**




During processing of rice grains for consumption, most rice is 'polished' leaving only starch-containing tissue. This is called white rice. Brown rice retains fibre and protein-containing tissues.

*(a)* (i) Using the letters **X**, **Y** and **Z**, identify the following: [3]

I. the structure that would stain blue-black on application of iodine solution.

.........................

II. the source of gibberellins during germination of a rice grain. .........................

III. the main source of amino acids for a germinating rice grain. .........................

(ii) Most rice consumed in Asian countries is white rice. In some areas rice makes up 80 to 90% of the diet. Suggest how and why the processing of rice has led to reduced growth rates of children in some communities. [2]

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**Turn over.**

Examiner only

Vitamin A deficiency is a world-wide problem. Rice can be genetically modified to include the gene coding for beta carotene which is then used in the production of vitamin A. This modified rice is yellow in colour and is called 'golden rice'.

In the first experiments to genetically modify rice, a pathogenic bacterium, *Agrobacterium tumefaciens*, was used to transfer the genes required to produce beta carotene into rice cells using modified plasmids.

*(b)* Name and describe the function of **two** enzymes that could have been used to produce the modified plasmids transferred to *A. tumefaciens*. [2]

Enzyme 1 ..........

Function ..........

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Enzyme 2 ..........

Function ..........

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*(c)* One of the genes required for beta carotene synthesis was obtained from daffodil DNA. Due to the presence of introns in the daffodil gene, a better option might be to use a synthetic DNA sequence derived from mRNA rather than using a gene extracted directly from a daffodil chromosome.

(i) State what is meant by an *intron*. [1]

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Examiner only

(ii) Explain how post transcriptional modification of mRNA (splicing) in eukaryotic cells provides evidence against the 'one gene one polypeptide' hypothesis. [2]

(iii) Explain why a synthetic DNA sequence derived from mRNA might be the better option for genetically modifying rice cells. [3]

(iv) Outline the process by which a synthetic daffodil gene could be prepared from mRNA. [3]

Examiner only

(d) The production of 'golden rice' is still in progress despite trials showing that humans can utilise the beta carotene contained in 'golden rice' to produce vitamin A. Suggest why people may still be opposed to the wide-scale growing and use of 'golden rice'. [2]

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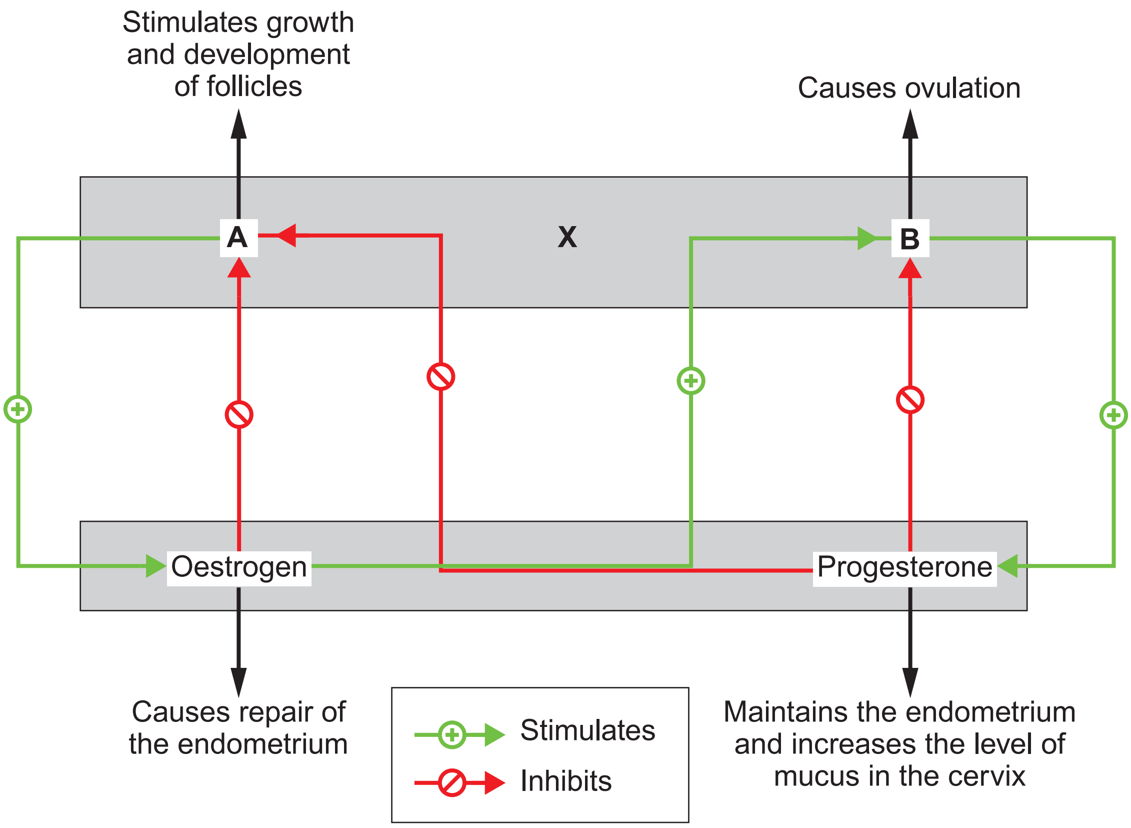
**5.** The menstrual cycle is controlled by the interaction of a number of different hormones as shown in the flow chart in **image 5.1**.

**Image 5.1**




*(a)* (i) State the names of the hormones labelled **A** and **B** in **image 5.1** and the name of structure **X** where they are secreted into the blood. [2]

**A** ..............................................................................................

**B** ..............................................................................................

**X** ..............................................................................................



Examiner only

(ii) With reference to **image 5.1**, conclude how oestrogen and progesterone in the combined contraceptive pill, act to reduce the likelihood of fertilisation. [3]

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Sperm production in human males is also dependent on the interaction of hormones **A** and **B** and their effects on different organs and tissues.

*(b)* State the following:

(i) the term used to describe the process of sperm production. [1]

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(ii) the precise location of sperm production in human males. [1]

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Examiner only

*(c)* Research into the development of a male contraceptive has focussed on reducing the production of spermatozoa. One possible method has been to increase the blood concentration of testosterone by administering a drug called TU.

One study involved 898 Chinese men between 20 and 45 years of age. All men starting the trial had fathered a child in the previous two years. Following an initial dose of 1000 mg, the men were all given an injection of 500 mg of TU each month for 30 months.

(i) Calculate the total mass of TU given to each man during the period of the trial. **Give your answer in grams.** [2]

mass of TU = .............................. g

(ii) State **two** criteria that were used to select the men included in the trial. [2]

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(iii) Semen samples were collected on a regular basis and the number of spermatozoa per $cm^3$ determined.
Of the original 898 men in the trial, 4.8% did not respond to the drug and remained fertile. Calculate the number of men who did respond to the drug. [2]

number of men who did respond to the drug = ..............................

(iv) The number of pregnancies in the partners of the men in the trial was also recorded. Suggest why sperm counts were carried out during the trial rather than relying on pregnancy rate alone as a measure of contraceptive success. [1]

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*(d)* Similar trials in other parts of the world have produced different degrees of success. Identify **two** changes to the study to validate the use of TU as a male contraceptive world-wide. Justify your suggested changes. [2]

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Examiner only

**6.** Ferns are terrestrial, non-flowering plants that first appeared in the fossil record about 360 million years ago. They are similar to other terrestrial plants in that they have vascular systems for transport of water, ions and products of photosynthesis around the plant. **Image 6.1** shows the leaves of a fern plant.

**Image 6.1**

*(a)* (i) Name the vascular tissues you would expect to find in ferns. [1]

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(ii) Ferns have chloroplasts with the same structure and photosynthetic pigments as flowering plants. Name **two** photosynthetic pigments found in ferns and state **precisely** where in the chloroplast you would expect to find them. [2]

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(iii) Identify the type of nutrition found in ferns. [1]

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Examiner only

Classification of ferns was originally based on morphological features, but cross-fertilisation between unrelated species has produced hybrids that have often been classified as different species.

In recent years, analysis of the chloroplast genome has enabled botanists to identify hybrid forms as the chloroplast is inherited only from the female gamete.

**Image 6.2** shows the gel electrophoresis of digested chloroplast DNA from four species of *Asplenium* fern. A DNA ladder was included to estimate the length of DNA fragments from the species of fern in number of base pairs.

**Image 6.2**

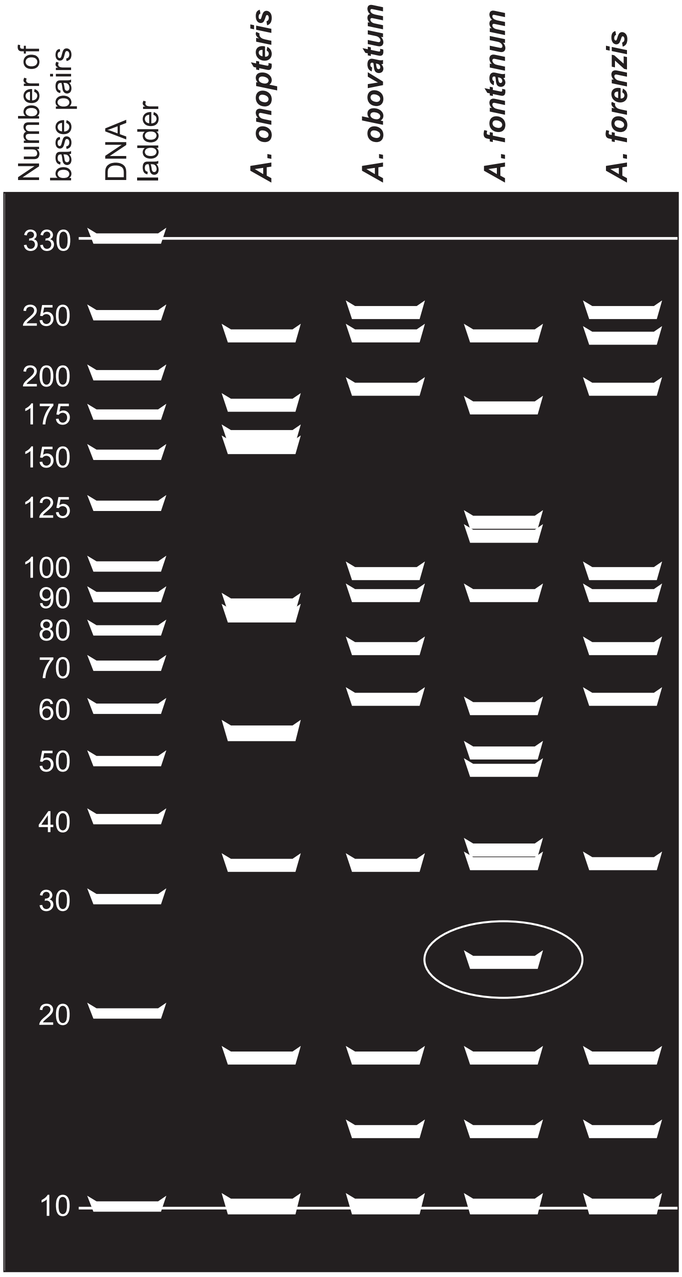



**Table 6.3**

| number of base pairs | $\log_{10}$ number of base pairs | distance travelled / mm |
|---|---|---|
| 10 | 1.00 | 128 |
| 20 | 1.30 | 103 |
| 30 | 1.47 | 88 |
| 40 | 1.60 | 78 |
| 50 | 1.70 | 70 |
| 60 | 1.78 | 63 |
| 70 | 1.85 | 57 |
| 80 | 1.90 | 53 |
| 90 | 1.95 | 48 |
| 100 | 2.00 | 44 |
| 125 | 2.10 | 36 |
| 150 | ............................ | 30 |
| 175 | 2.24 | 25 |
| 200 | 2.30 | 19 |
| 250 | ............................ | 10 |
| 330 | 2.52 | 0 |

Examiner only

*(b)* (i) **Complete table 6.3** by calculating the $\log_{10}$ value of the number of base pairs in the DNA fragments in the DNA ladder. [1]

(ii) **Graph 6.4** shows some of the data from **table 6.3**.

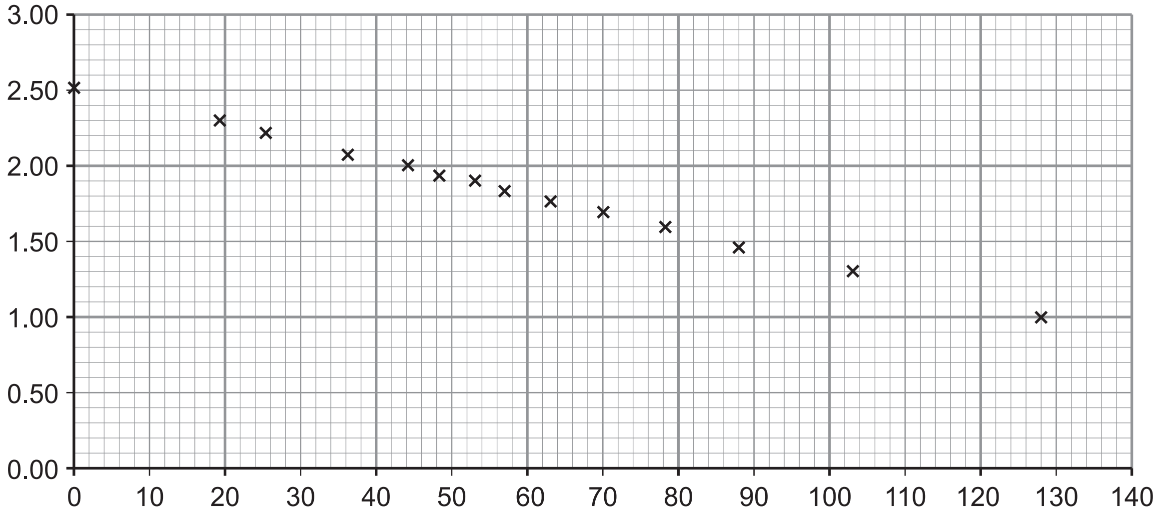
On **graph 6.4**:

I. label the axes [1]

II. plot the values for 10 mm and 30 mm [1]

III. draw a line of best fit through the plots. [1]

**Graph 6.4**




(iii) I. One fragment from *A. fontanum* has a circle drawn around it on the gel electrophoresis in **image 6.2**. This fragment travelled a distance of 95 mm. Use **graph 6.4** to estimate the $\log_{10}$ of the number of base pairs in this fragment. **Show how you estimated this value on graph 6.4**. [2]

$\text{Log}_{10}$ estimated number of base pairs in DNA fragment = ..............................

II. If $100 = 10^2$, then $\log_{10} 100 = 2$ and $10^2 = 100$.
Use this relationship and your answer to the previous question to determine the estimated number of base pairs in this fragment. [1]

Estimated number of base pairs in DNA fragment = ..............................

Examiner only

(iv) Suggest how you could modify the method to estimate the length of this DNA fragment more accurately. [1]

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(v) It is known that *A. forenzis* is a hybrid of *A. fontanum* and one of the other two species shown on the gel electrophoresis in **image 6.2**. Use the information given to conclude which species provided the female gamete to produce the hybrid *A. forenzis*. Explain your answer. [3]

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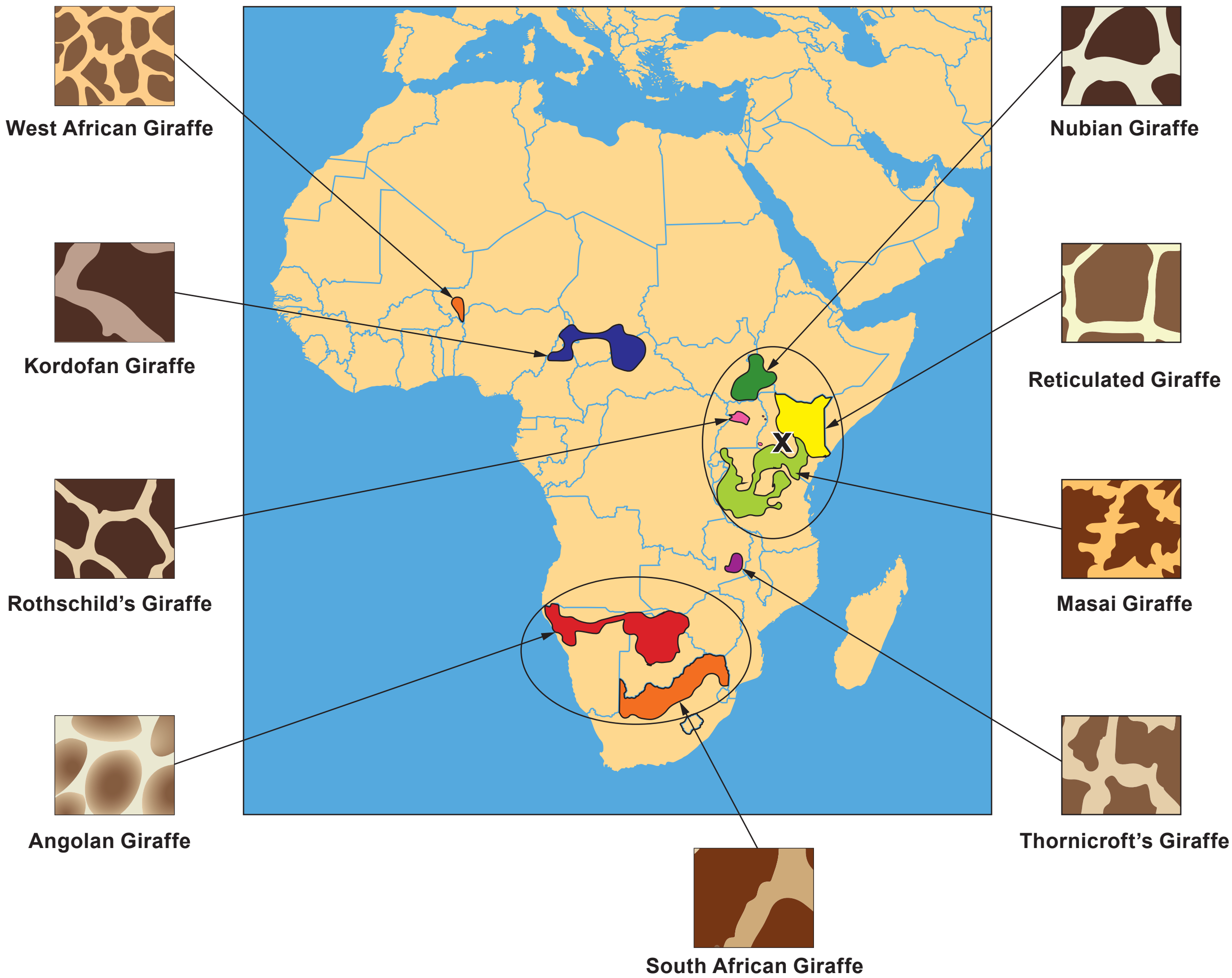
**7.** Today, there are an estimated 1 500 giraffes held in captivity and approximately 90 000 in the wild. There are several different coat patterns that are similar to each other but are different in colouration and size of coloured areas in different populations. Giraffes live in a range of habitats 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 7.1** shows the current distribution of the proposed different species of giraffe together with their typical coat patterns.

**Image 7.1**




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.

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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]

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