UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/41**

Paper 4 A2 Structured Questions **October/November 2013**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name in the spaces provided at the top of this page.
Write in dark blue or black ink.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.
Circle the number of the Section B question you have answered in the grid below.

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.

Electronic calculators may be used.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Section B	
10 or 11	
Total	

This document consists of **22** printed pages, **1** blank page and **1** lined page.

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Section A

For Examiner's Use

Answer **all** questions.

1 **(a)** Huntington's disease (HD) is an inherited disease of the central nervous system. The symptoms of HD usually develop in adulthood and include uncontrollable muscular movements, short-term memory loss and changes in mood.

HD is caused by a dominant allele of the *huntingtin* gene on chromosome 4.

Explain what is meant by the terms *allele* and *dominant.*

allele .....

.....

dominant .....

..... [2]

(b) The dominant allele of the *huntingtin* gene contains many repeats of a triplet sequence of nucleotides, CAG. The age at which symptoms of HD first appear is linked with the number of CAG repeats.

This is shown in Fig. 1.1.

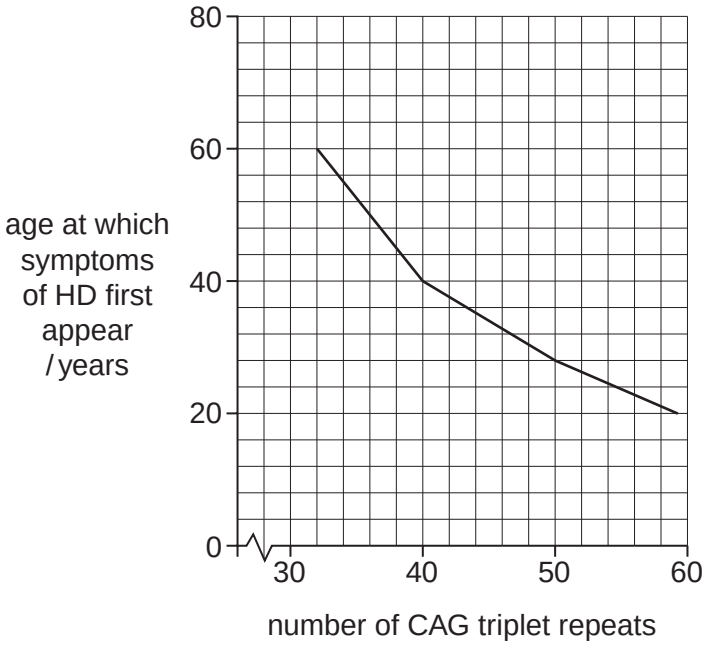


Fig. 1.1

Describe the pattern shown in Fig. 1.1.

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(c) A blood test to detect the dominant allele is available for people at risk of HD.

Suggest why some people at risk of HD may decide **not** to take the blood test.

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[Total: 7]

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2 Mammoths are extinct mammals related to elephants. About three million years ago, the ancestors of mammoths migrated from Africa into Europe and Asia. There, about 1.7 million years ago, the steppe mammoth evolved and became adapted to the cooler conditions. Then, about 700 000 years ago, as the climate changed and the Arctic became much colder, the woolly mammoth evolved.

Woolly mammoths showed a number of obvious adaptations to reduce heat loss, including thick fur, small ears and small tails.

(a) Explain how variation and natural selection may have brought about the evolution of the woolly mammoth from the steppe mammoth.

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(b) A frozen, 43 000 year old woolly mammoth was found in Siberia. Its DNA was extracted and sequenced. The sequences of the genes coding for the α and β chains of haemoglobin were compared with those of modern Asian elephants.

The results suggested that, when compared with Asian elephants:

- there was only one different amino acid in the woolly mammoth's α chains
- there were three different amino acids in the woolly mammoth's β chains.

Explain the likely effect of these differences on a molecule of mammoth haemoglobin.

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[Turn over

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(c) Scientists synthesised woolly mammoth haemoglobin in order to investigate whether or not the different haemoglobin was part of the mammoth's adaptation to a cold climate.

The affinity of haemoglobin for oxygen is affected by the changes in temperature that can occur in mammals, for example in active muscle tissue or close to the skin surface.

It is advantageous for Arctic mammals to have haemoglobin whose affinity for oxygen is only slightly affected by changes in temperature. This is often achieved by using substances called 'red cell effectors', which bind to haemoglobin.

Fig. 2.1 compares the effect of temperature on the affinity for oxygen of woolly mammoth and Asian elephant haemoglobin, with and without red cell effectors.

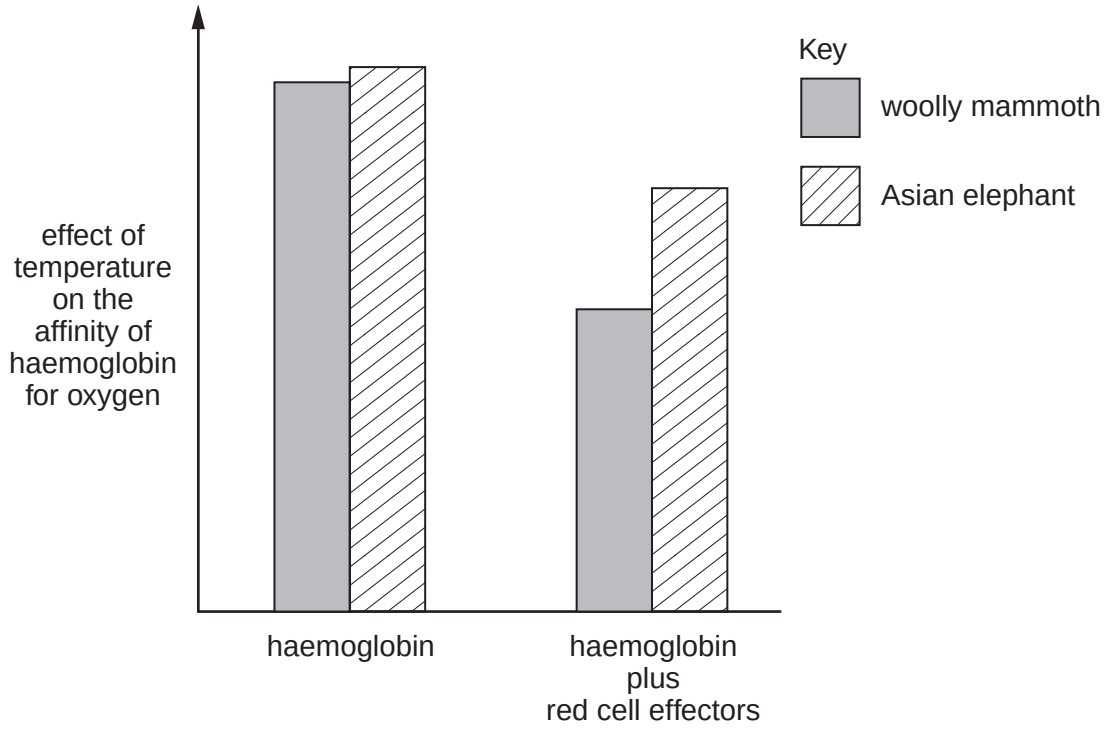


Fig. 2.1

(i) Suggest why it is advantageous for Arctic mammals to have haemoglobin whose affinity for oxygen is only slightly affected by changes in temperature.

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(ii) Explain whether or not Fig. 2.1 provides evidence that woolly mammoth haemoglobin is better adapted for a cold climate than Asian elephant haemoglobin.

For Examiner's Use

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[Total: 14]

3 **(a)** The components of a molecule of ATP (adenosine triphosphate) are shown in Fig. 3.1.

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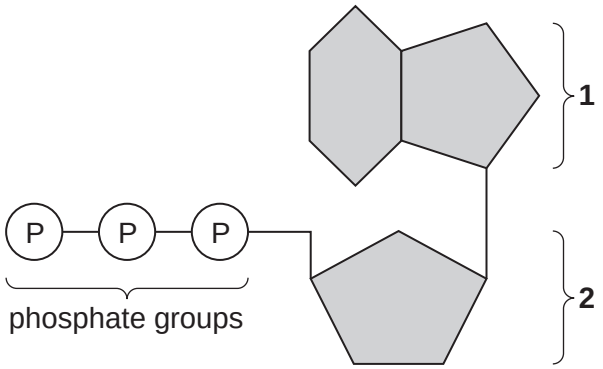


Fig. 3.1

With reference to Fig. 3.1, name components **1** and **2**.

1 .....

2 ..... [2]

(b) Describe the consequences for the cell of the following statements.

- Each cell has only a very small quantity of ATP in it at any one time.
- The molecules, ATP, ADP (adenosine diphosphate) or AMP (adenosine monophosphate) **rarely** pass through the cell surface membrane.

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(c) Glucose is a respiratory substrate. Table 3.1 shows the yield of ATP from some other substrates.

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Table 3.1

respiratory substrate	number of ATP molecules produced per mole of substrate
alanine (an amino acid)	15
glycogen	39
lactate	18
palmitic acid (a fatty acid)	129

(i) Explain the different yields of ATP from glycogen and palmitic acid.

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(ii) Describe the circumstances in which alanine and lactate are used as respiratory substrates.

alanine .....

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lactate .....

.....[2]

[Total: 8]

4 **(a)** Blood samples were taken from a 29 year old woman each day for a period of 43 days. The concentrations of oestrogen, progesterone and luteinising hormone (LH) in each sample were measured. The results are shown in Fig. 4.1.

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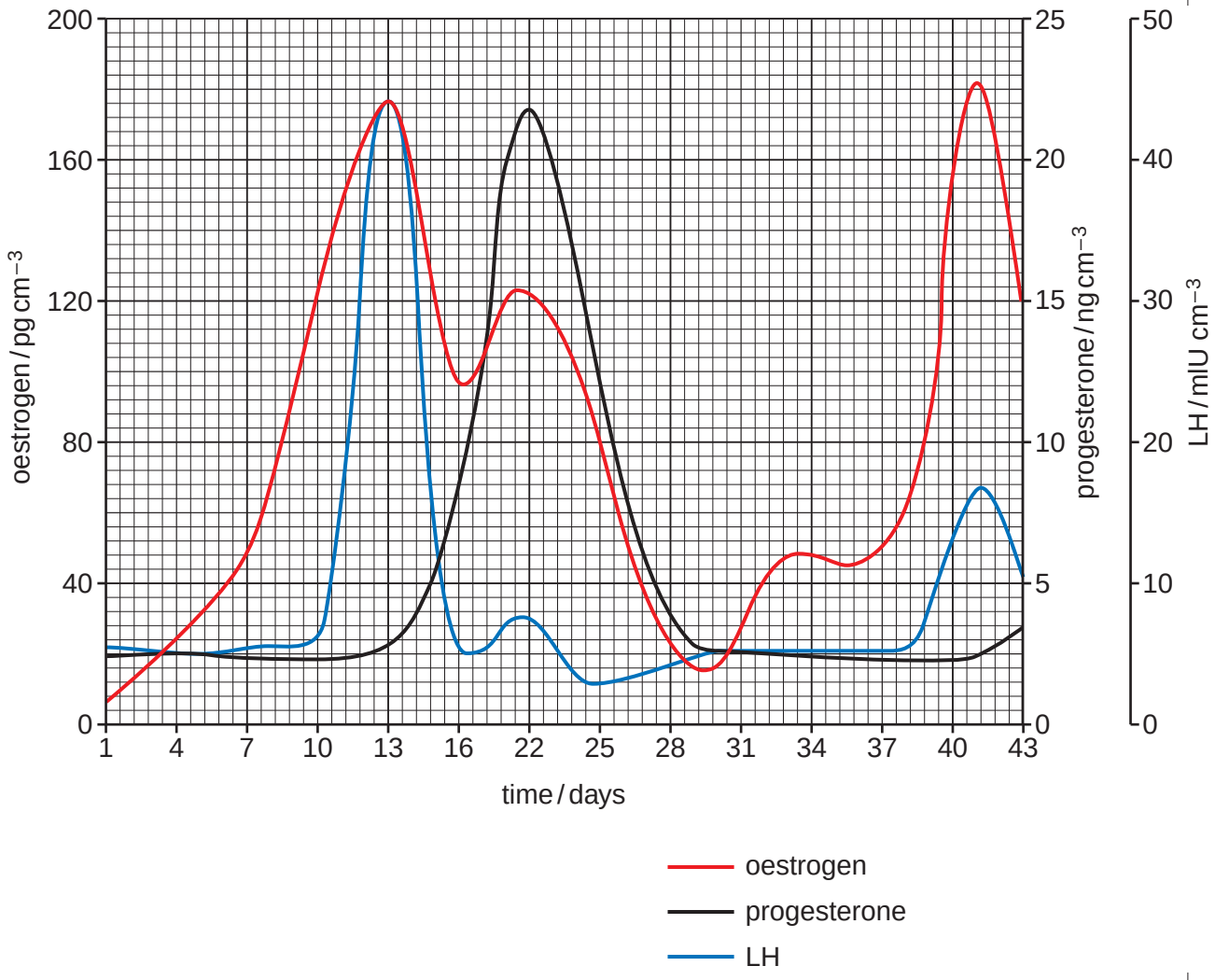


Fig. 4.1

(i) Estimate the length of the woman's menstrual cycle. Show how you worked out your answer.

answer ..... (days) [2]

(ii) The luteal phase is the part of the cycle when a corpus luteum is present in the ovaries. It begins immediately after ovulation, and ends when menstruation starts.

Use Fig. 4.1 to suggest when the luteal phase began and ended.

began ..... *ended* ..... [2]

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(iii) Name the organ that secretes LH.

.....[1]

(iv) Describe the roles of LH in the menstrual cycle.

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(b) An investigation was carried out to determine whether the ability of a woman to perform a task involving spatial ability varied at different times of her menstrual cycle.

The investigation involved 12 women. They each performed 24 similar spatial tasks on day 2 and day 22 of their menstrual cycle, for six successive cycles. The tasks involved mentally rotating 3-D shapes.

The researchers used two methods to determine the phase of the menstrual cycle.

- Each woman was asked when her previous menstrual period had begun.
- After each test, a blood sample was taken and the concentrations of oestrogen, progesterone and LH were measured.

(i) Suggest why the researchers used two methods to determine the phase of the menstrual cycle.

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.....[2]

(ii) The mean score for women taking the tests on day 2 of their cycle was 10.50 out of 24. The mean score for women taking the tests on day 22 of their cycle was 7.38 out of 24.

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Discuss whether or not these results support the hypothesis that the concentration of oestrogen in the blood affects the ability to perform spatial tasks.

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[Total: 14]

5 **(a)** Maize originated in the Americas, and 55% of the world's maize production is from this part of the world.

For Examiner's Use

Fig. 5.1 shows the mean yields of maize in the USA between 1860 and 2010.

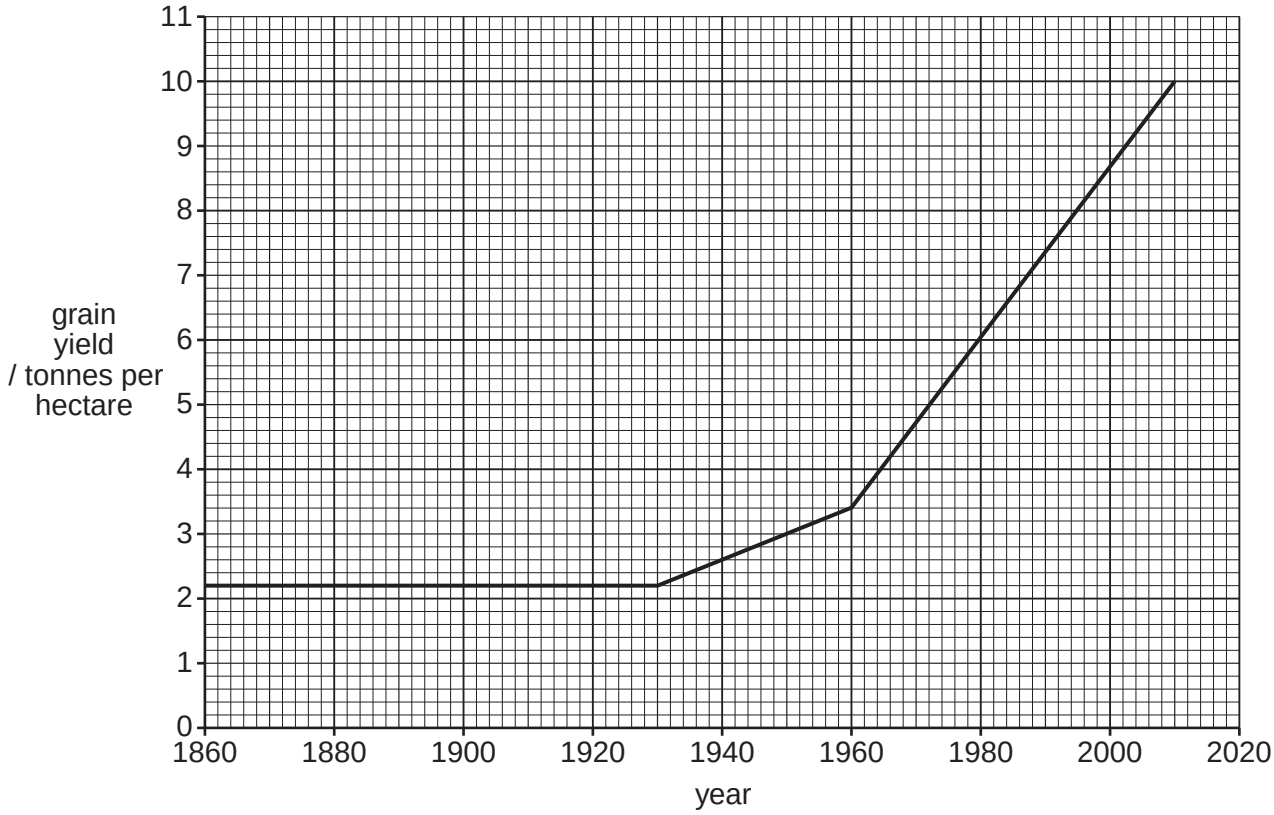


Fig. 5.1

Describe the changes in grain yield between 1860 and 2010.

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For Examiner's Use

(b) The greatest improvement in maize yields came after growers realised that maize hybrids have a much greater yield than inbred lines.

Between 1860 and the 1930s, maize was allowed to pollinate naturally in the field. From the 1930s onward, maize seed was produced using 'double-cross' hybrids.

To produce a double-cross hybrid:

- two different maize plants, **A** and **B**, are crossed to produce a hybrid, **C**
- two other maize plants, **X** and **Y**, are crossed to produce a hybrid, **Z**
- the hybrid **C** is then crossed with the hybrid **Z**, to produce the double-cross hybrid.

From 1960 onwards, maize seed was produced using 'single-cross' hybrids. This involves crossing one inbred (entirely homozygous) plant with a different inbred plant.

Explain why single-cross hybrids are genetically uniform, but double-cross hybrids are not.

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(c) An experiment was carried out in 1996–1997 to investigate the relative effects of genotype and environment on the yield of maize.

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Maize seeds with different 'inbreeding coefficients' were used. The greater the inbreeding coefficient, the greater the degree of homozygosity in the maize plants.

Maize seeds with different inbreeding coefficients were planted in two different areas in 1996, and in the same two areas in 1997.

Fig. 5.2 shows the results.

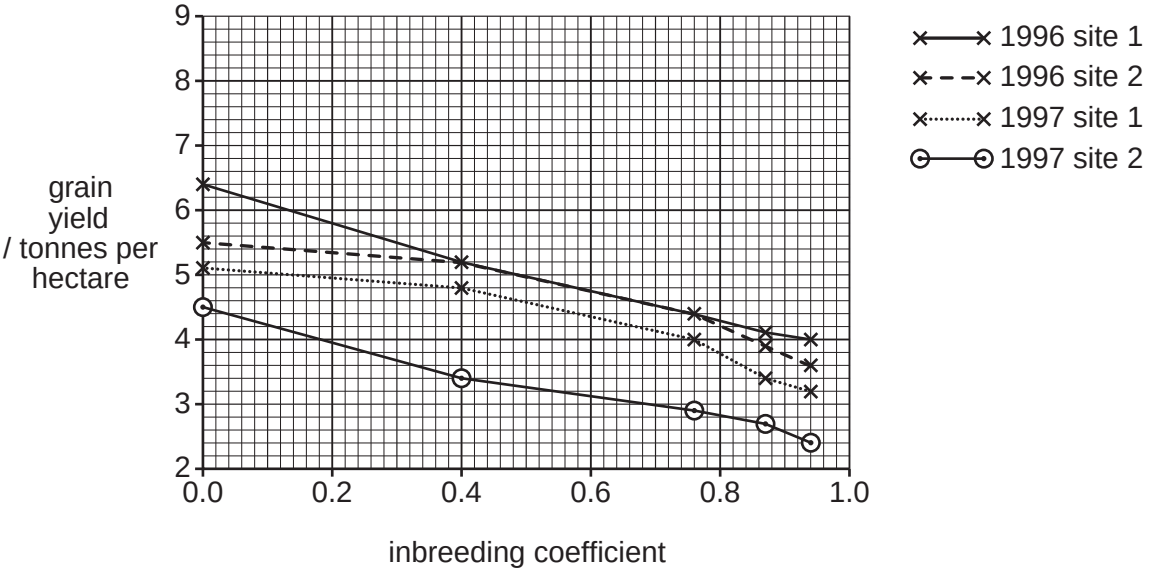


Fig. 5.2

(i) Inbreeding depression is a reduction in vigour that results from inbreeding.

Explain how the results in Fig. 5.2 demonstrate inbreeding depression in maize.

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(ii) Explain how the results in Fig. 5.2 show that the environment affects maize yields.

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[Total: 10]

For Examiner's Use

6 **(a)** Table 6.1 shows the mean axon diameter and mean speed of conduction of nerve impulses for four different animals.

Table 6.1

animal	type of neurone	axon diameter / μm	mean speed of conduction / ms^{-1}
A – mammal	myelinated	4	25
B – mammal	unmyelinated	5	3
C – amphibian	myelinated	14	35
D – amphibian	myelinated	10	30

With reference to Table 6.1, describe:

(i) the effect of myelination on the speed of conduction of impulses in mammals

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.....[2]

(ii) the effect of axon diameter on the speed of conduction of impulses in amphibians.

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(b) Explain how myelination affects the speed of conduction of impulses.

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(c) Multiple sclerosis (MS) is an auto-immune condition of humans in which the body's immune system attacks the myelin sheaths which are then damaged. This leads to a decrease in information reaching the brain from sensory receptors.

For Examiner's Use

(i) Suggest how the myelin sheaths may be attacked.

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(ii) Explain why this damage leads to a decrease in information reaching the brain from sensory receptors.

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[Total: 11]

For Examiner's Use

7 **(a)** An experiment was carried out into the effect of light of different colours on photosynthesis.

- 15 leaf discs from the same plant were obtained.
- Five sealed test-tubes were set up, each containing three leaf discs in hydrogencarbonate indicator solution.
- Hydrogencarbonate indicator solution changes colour at different pH values.
- At the start of the experiment the indicator solution in all five test-tubes was orange-red.
- Four of the test-tubes were illuminated by light of a specific colour.
- The test-tubes were illuminated for the same length of time.
- The fifth test-tube was covered in black paper and was a control.

The results are recorded in Table 7.1.

Table 7.1

colour of light	final colour of hydrogencarbonate solution
white	purple
blue	purple
green	orange-yellow
red	purple
control – no light	yellow

When the pH increases, the indicator becomes purple and when the pH decreases, the indicator turns yellow.

(i) Explain the results for the leaf discs illuminated by blue light.

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.....[2]

(ii) Explain why the indicator in the control went yellow.

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.....[2]

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(b) Cyclic and non-cyclic photophosphorylation take place in the light-dependent stage of photosynthesis.

For Examiner's Use

(i) Describe the role of accessory pigments in photophosphorylation.

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.....[2]

(ii) Write a balanced equation that summarises photolysis.

.....[1]

(iii) State **precisely** the location of photosynthetic pigments within a chloroplast.

.....[1]

[Total: 8]

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8 **(a)** The tiger, *Panthera tigris*, is classified as an endangered species by the International Union for the Conservation of Nature and Natural Resources (IUCN). The IUCN publishes an annual list of endangered species called the Red List.

For Examiner's Use

Fig. 8.1 shows the number of tigers in the wild between 1900 and 2010.

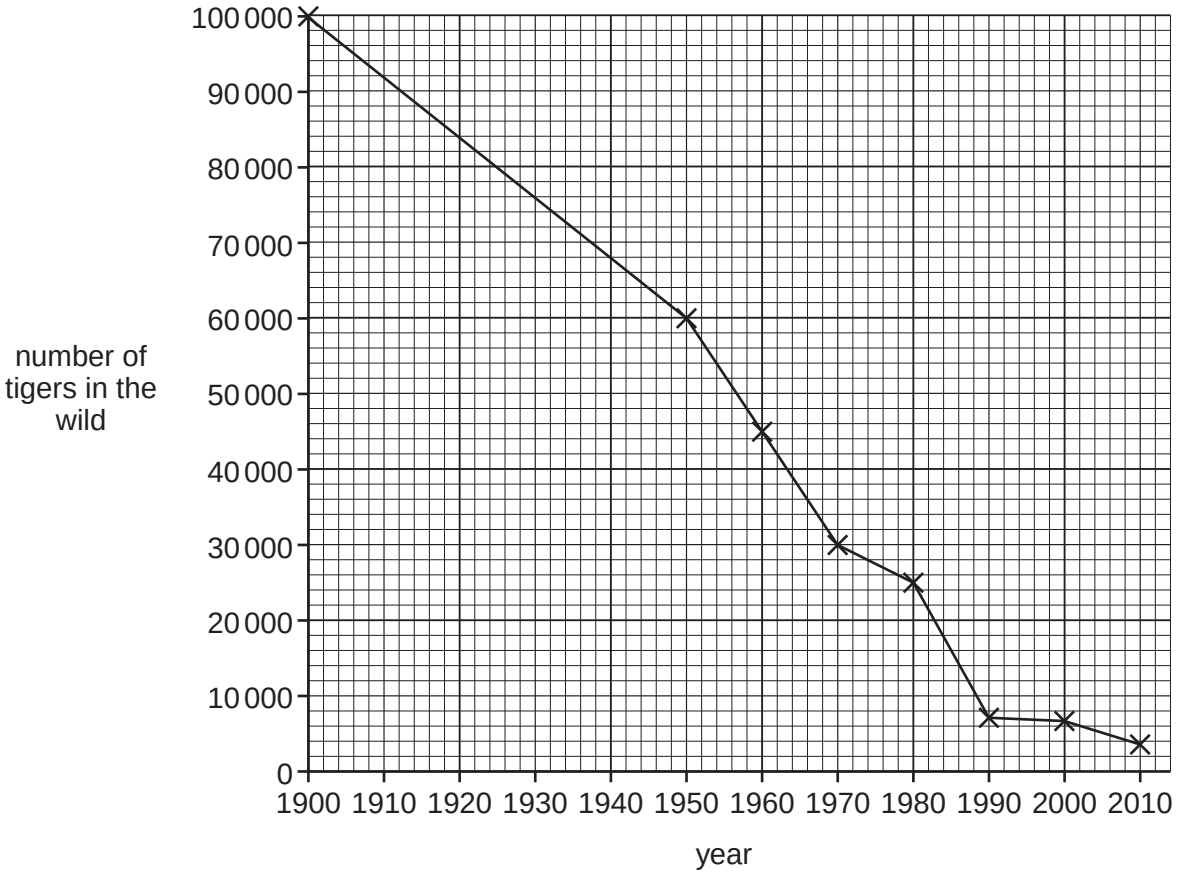


Fig. 8.1

Calculate the overall rate of decrease in number of tigers between 1900 and 2010.

Give your answer to the **nearest whole number**.

answer ..... tigers per year [2]

(b) Describe the reasons why a **named** species has become endangered.

For Examiner's Use

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[Total: 6]

9 The passage below summarises the effects of gibberellins on seed germination.

Complete the passage by using the most appropriate scientific term(s).

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When a seed is shed from the parent plant, it is in a state of …… , which means it is metabolically inactive.

When water is absorbed by a seed, it stimulates the production of gibberellin by the …… within the seed. The gibberellin stimulates the synthesis of amylase by cells in the …… layer.

Amylase hydrolyses starch molecules in the …… converting them to soluble …… molecules. These molecules are converted to glucose which is transported to the embryo, providing a source of carbohydrate that can be respired to provide …… as the embryo begins to grow.

Gibberellin causes these effects by regulating genes that are involved in the synthesis of amylase. It has been shown that application of gibberellin to seeds can cause an increase in the …… of the DNA coding for amylase.

[Total: 7]

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Section B

Answer **one** question.

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10 **(a)** Explain what is meant by a **gene** mutation and outline the possible consequences of a gene mutation for an organism. [9]

(b) Explain how faulty CFTR proteins in cell surface membranes can lead to the symptoms of cystic fibrosis. [6]

[Total: 15]

11 **(a)** Describe the main features of an organism belonging to the plant kingdom. [7]

(b) Describe the structure of a mitochondrion and outline its function in a plant cell. [8]

[Total: 15]

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