UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9579071857

BIOLOGY **9700/41**

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

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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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	
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7	
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9	
Section B	
10 or 11	
Total	

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UNIVERSITY of CAMBRIDGE International Examinations

Section A

Answer **all** questions.

For Examiner's Use

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.

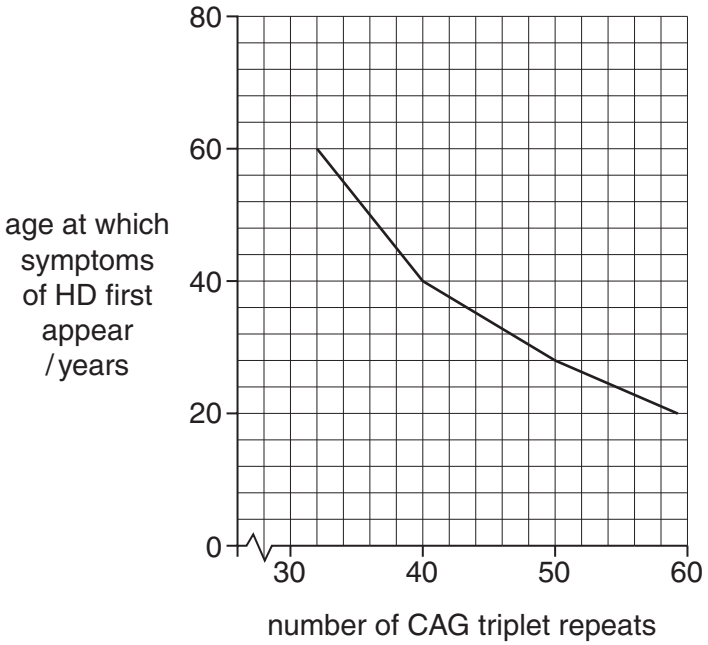


Fig. 1.1

Describe the pattern shown in Fig. 1.1.

For Examiner's Use

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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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For Examiner's Use

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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For Examiner's Use

(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.

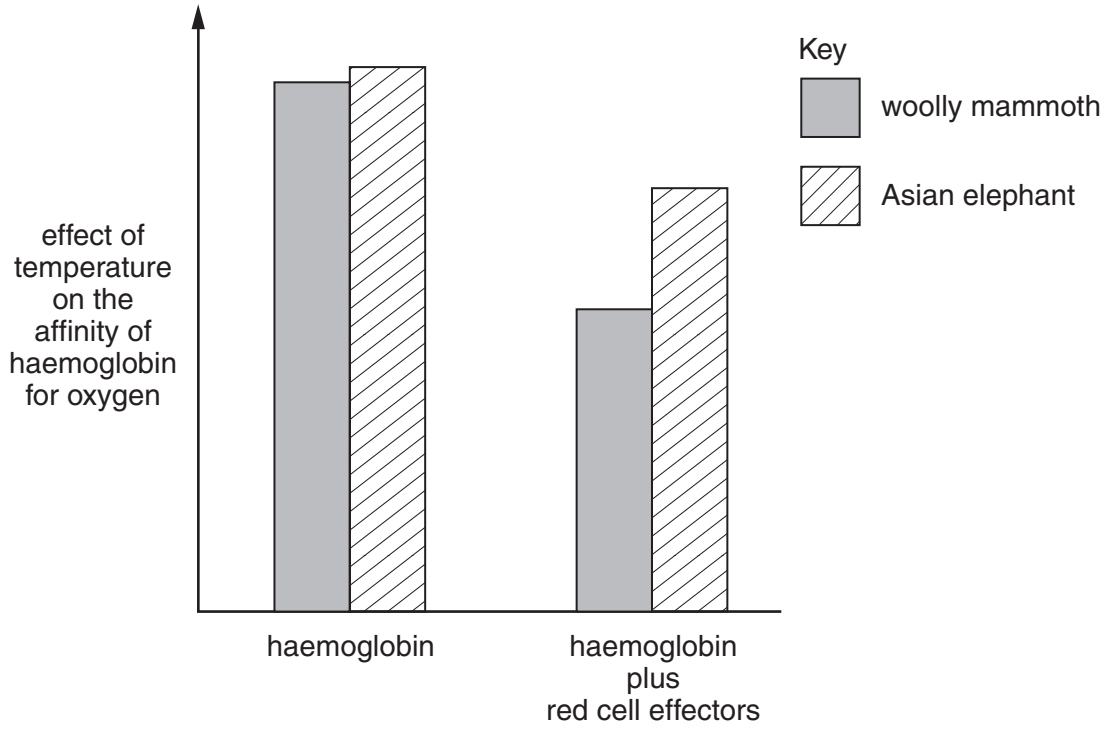


Fig. 2.1

(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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.....[2]

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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]

For Examiner's Use

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

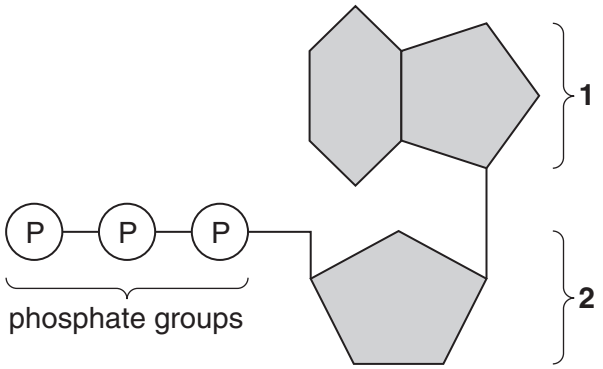


Fig. 3.1

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.

For Examiner's Use

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 .....

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[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.

For Examiner's Use

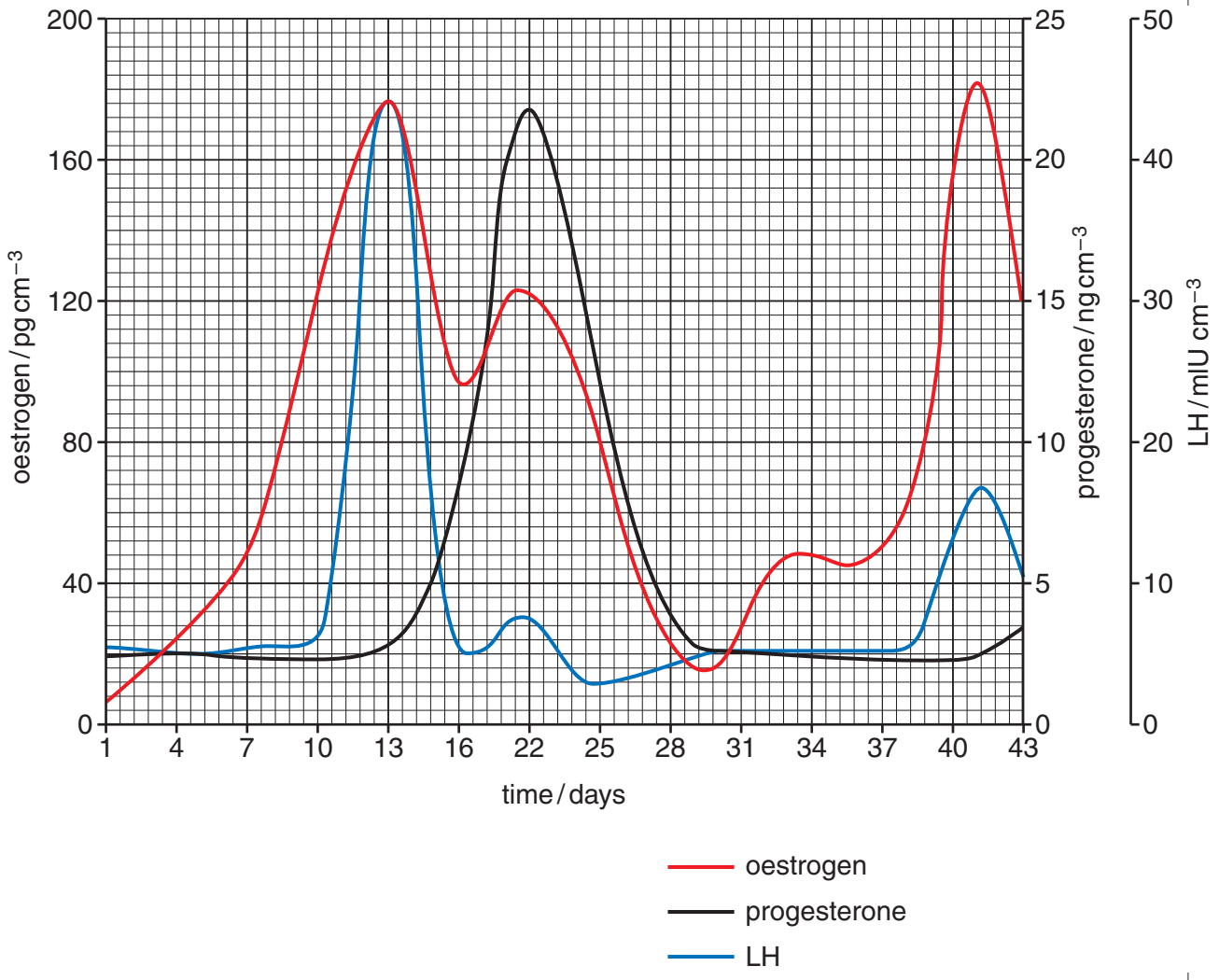


Fig. 4.1

(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]

For Examiner's Use

(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.

For Examiner's Use

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.

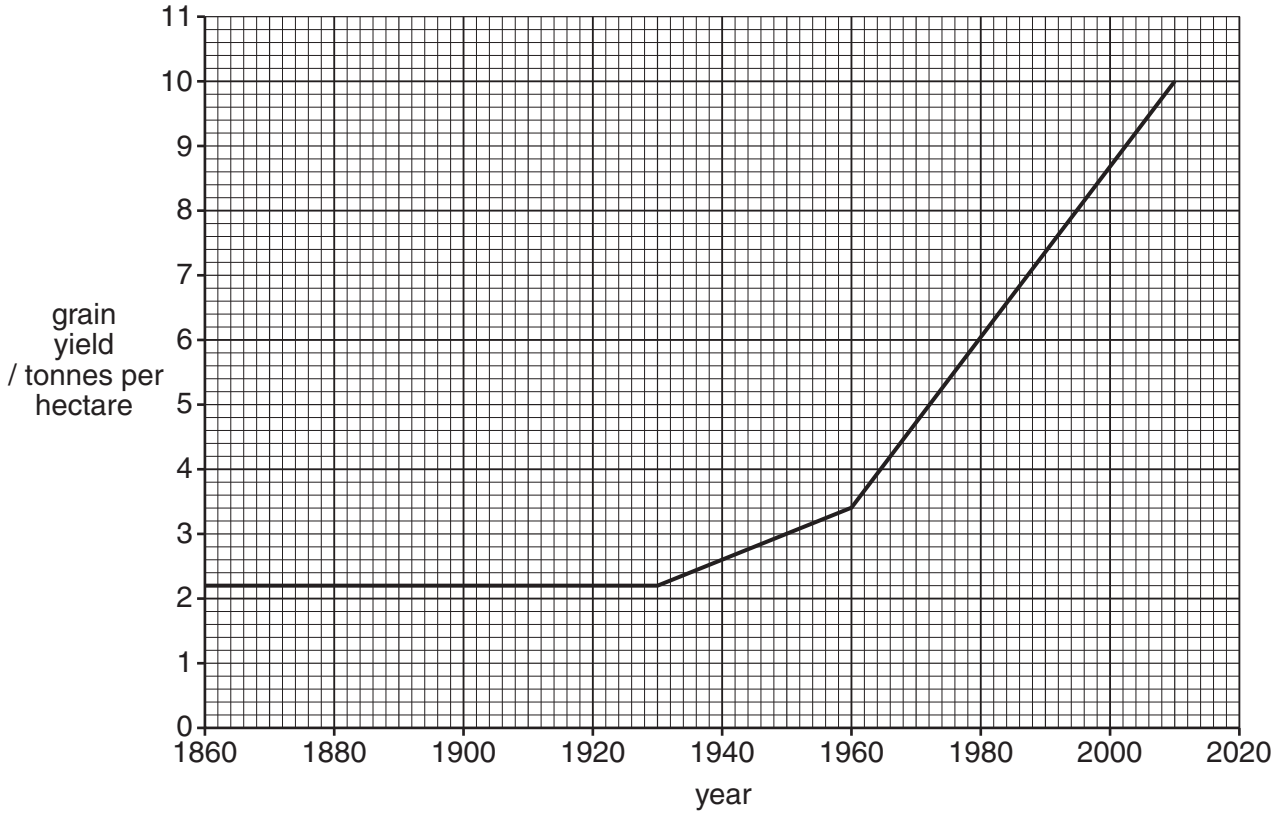


Fig. 5.1

Describe the changes in grain yield between 1860 and 2010.

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.....[3]

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

For Examiner's Use

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.

For Examiner's Use

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.

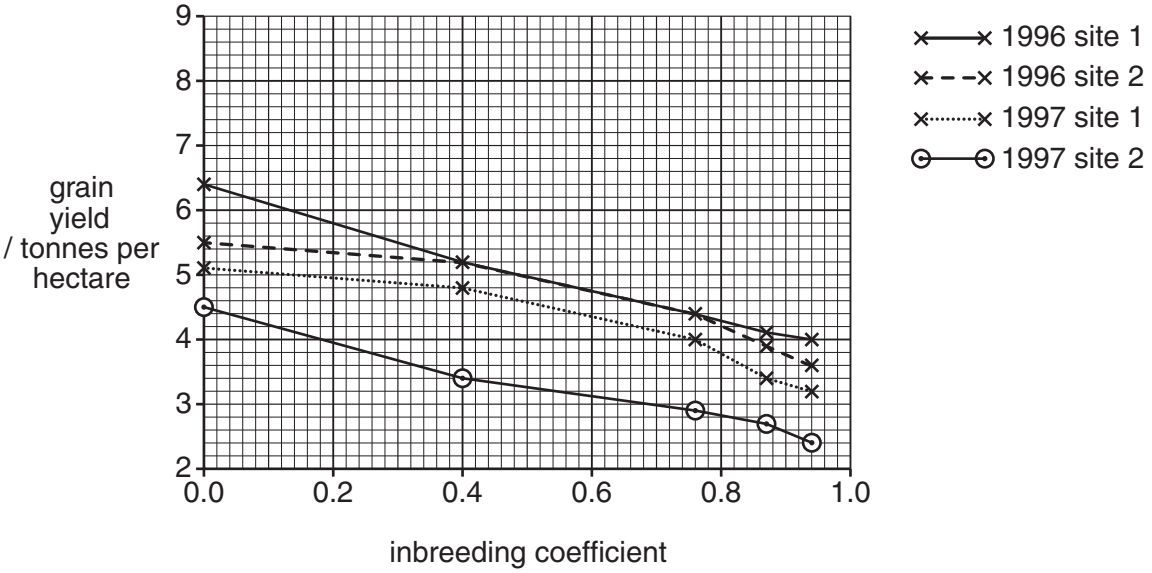


Fig. 5.2

(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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.....[3]

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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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(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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(ii) Write a balanced equation that summarises photolysis.

.....[1]

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

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[Total: 8]

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[Turn over

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.

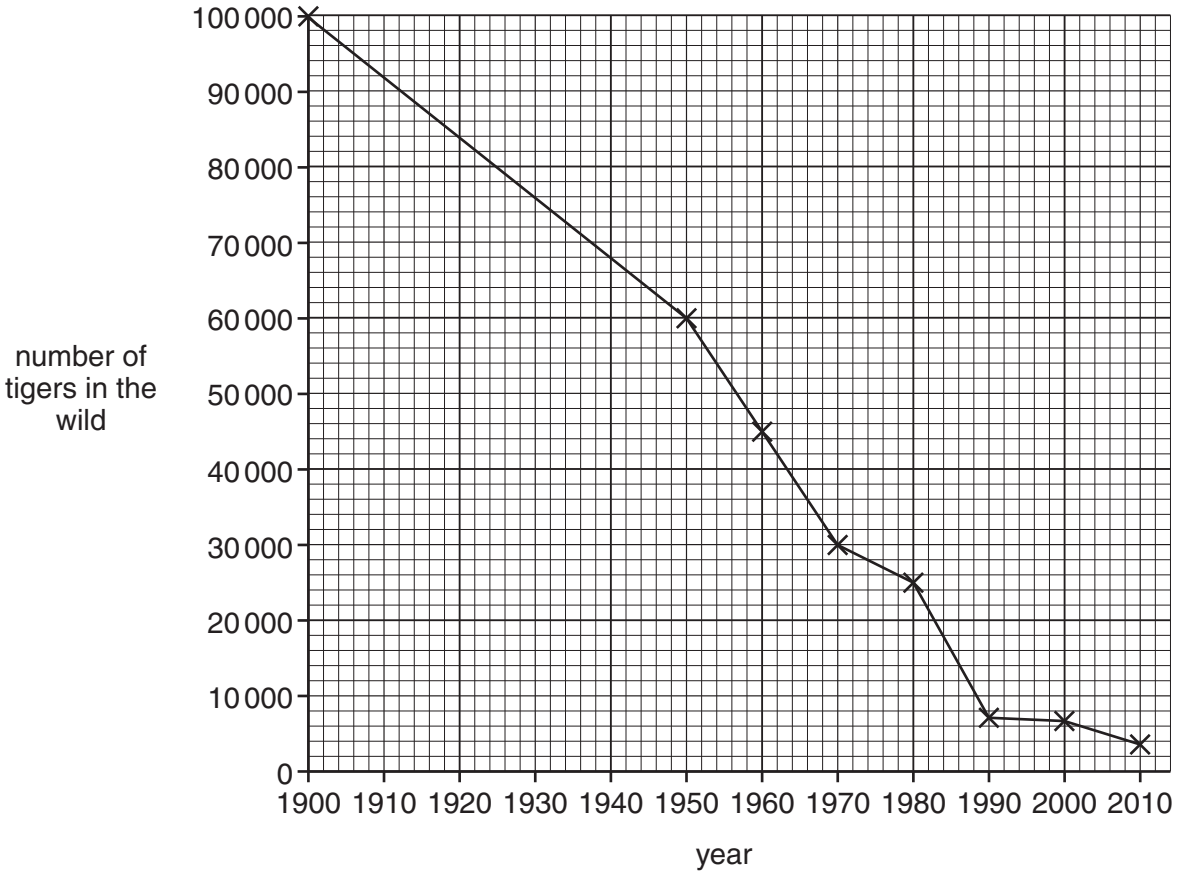


Fig. 8.1

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).

For Examiner's Use

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.

For Examiner's Use

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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BIOLOGY **9700/43**

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

2 hours

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For Examiner's Use	
Section A	
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Section A

For Examiner's Use

Answer **all** the questions.

1 A mutation in a gene in the fruit fly, *Drosophila melanogaster*, gives rise to white-eyed flies instead of the normal red-eyed flies. The allele for red eyes (**R**) is dominant to the allele for white eyes (**r**).

A student crossed a red-eyed fly with a white-eyed fly.

The results are shown in Table 1.1.

Table 1.1

phenotype of fly	number of offspring
red-eyed female	54
red-eyed male	0
white-eyed female	0
white-eyed male	46

(a) In *Drosophila*, males possess two different sex chromosomes, X and Y, as in humans.

Complete the genetic diagram below to show how the results in Table 1.1 could have been produced.

parental phenotypes red-eyed fly white-eyed fly

parental genotypes ☐ ☐

gametes ◯ ◯ ◯ ◯

offspring genotypes ☐ ☐

offspring phenotypes red-eyed female white-eyed male [3]

For Examiner's Use

(b) (i) The chi-squared (χ^2) test can be used to analyse the results in Table 1.1.

The expected ratio of red-eyed females to white-eyed males is 1:1.

Complete Table 1.2 and use this to calculate a value for chi-squared (χ^2).

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} \qquad v = n-1$$

key

Σ = sum of
v = degrees of freedom
n = number of classes
O = observed value
E = expected value

Table 1.2

phenotype of fly	O	E	O–E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
red-eyed female					
white-eyed male					

χ^2 = ...[3]

(ii) Use your calculated value of χ^2 and the table of probabilities below, to test the significance of the difference between observed and expected results.

degrees of freedom	probability			
	0.90	**0.50**	**0.10**	**0.05**
1	0.02	0.45	2.71	3.84
2	0.21	1.39	4.61	5.99

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.....[2]

[Total: 8]

For Examiner's Use

2 The evolutionary origin of the four-legged amphibians (such as frogs and toads) from fish has been the subject of much debate for many years.

Among living fish, the rarely-caught coelacanth and the lungfish are thought to be most closely related to these amphibians.

Samples of blood were taken from two coelacanths that were captured recently near Comoros.

The amino acid sequences of the α and β chains of coelacanth and lungfish haemoglobin were compared with the known sequences of amphibian adults and their aquatic larvae (tadpoles). Organisms with more matches in the amino acid sequence of a polypeptide chain share a more recent common ancestor than those with fewer matches.

The comparisons with three species of amphibians, *Xenopus laevis (Xl), X. tropicana (Xt) and Rana catesbeiana (Rc)* are shown in Table 2.1.

Table 2.1

		percentage of matches of amino acid sequence					
		species of amphibian adults			**species of amphibian larvae (tadpoles)**		
	fish species	*Xl*	*Xt*	*Rc*	*Xl*	*Xt*	*Rc*
α chains	coelacanth	42.0	47.5	no data	45.4	42.6	48.2
	lungfish	40.4	42.1	no data	40.7	39.0	37.9
β chains	coelacanth	42.1	43.2	40.7	52.1	52.1	58.2
	lungfish	44.1	45.9	41.4	47.3	45.9	48.6

(a) (i) Explain whether or not the information in Table 2.1 supports the suggestion that coelacanths and amphibians share a more recent common ancestor than do lungfish and amphibians.

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For Examiner's Use

(ii) Suggest why adults and tadpoles of the same species of amphibian have different amino acid sequences in their haemoglobin.

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.....[2]

(b) Coelacanth haemoglobin has a very high affinity for oxygen, suggesting that coelacanths, which have been captured at depths of between 200 m and 400 m, live in water that has a low concentration of oxygen.

Explain how an environmental factor, such as the low concentration of oxygen in deep water, can act:

(i) as a stabilising force in natural selection

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(ii) as an evolutionary force in natural selection.

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(c) Explain the role of isolating mechanisms in the evolution of new species.

For Examiner's Use

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[Total: 15]

For Examiner's Use

3 **(a)** Outline the role of oxygen in aerobic respiration.

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(b) Table 3.1 shows the results of some measurements of the energy released by different respiratory substrates and the water produced in the process.

Table 3.1

respiratory substrate	energy released / kJ		mass of water produced / g
	per g of substrate	per dm^3 of oxygen consumed	per g of substrate
carbohydrate	17.4	20.9	0.56
lipid	39.3	19.6	1.07
protein	17.8	18.6	0.45

(i) Describe **and** explain the differences in energy released by the three respiratory substrates.

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(ii) Suggest why more water is produced from the metabolism of lipid than from the other two substrates.

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.....[1]

[Total: 7]

For Examiner's Use

4 Many women use knowledge of their menstrual cycle as a family planning method, avoiding sexual intercourse during the part of the cycle when it is possible for fertilisation to occur. This part of the cycle is known as the fertile window.

In women with regular, 28-day menstrual cycles, ovulation is likely to take place on day 14. Most guidelines state that the fertile window lasts from day 10 to day 17 of the menstrual cycle.

(a) Explain why the fertile window begins several days before ovulation takes place.

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.....[2]

(b) Fig. 4.1 shows how basal body temperature, and the concentration of luteinising hormone, LH, varied during one menstrual cycle of a woman. Basal body temperature is the temperature of the body just after waking in the morning.

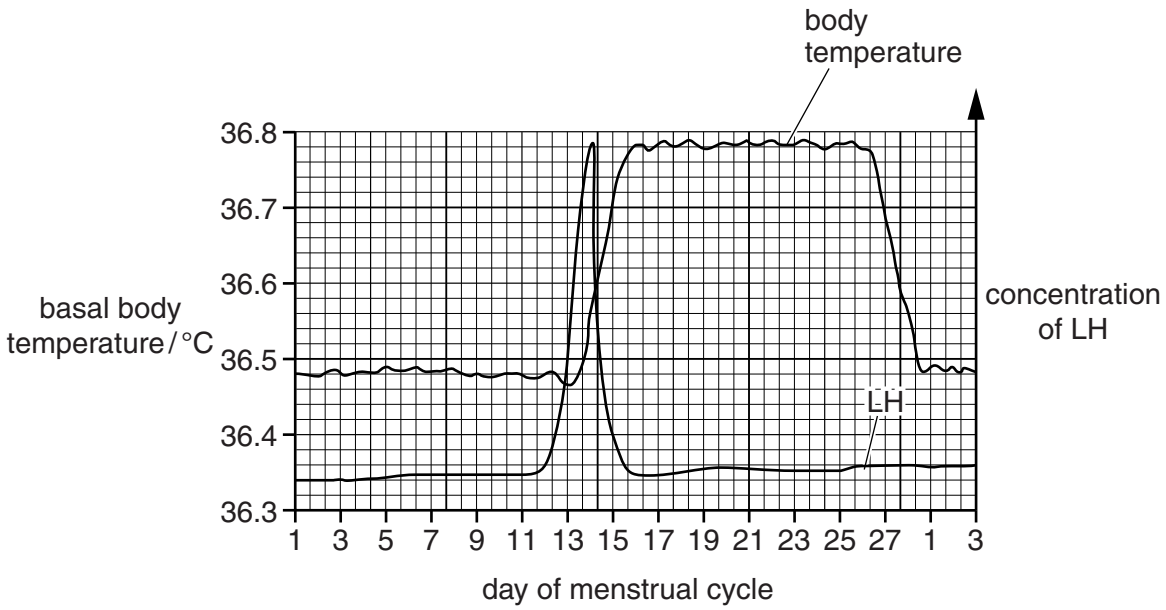


Fig. 4.1

(i) On Fig. 4.1, sketch a curve to show the changes in the concentration of progesterone in the blood during this menstrual cycle. [2]

(ii) The follicular phase of the menstrual cycle begins when menstruation starts, and ends when ovulation takes place.

With reference to Fig. 4.1, suggest when the follicular phase began and ended during this menstrual cycle.

began ..... *ended* ..... [1]

(c) Three methods that a woman can use for determining her fertile window are:

For Examiner's Use

method 1 using the date at which each menstruation begins to predict when ovulation will occur

method 2 using disposable urine dip sticks to measure the amount of LH breakdown products in urine (the more LH in the blood, the more breakdown products are present in urine)

method 3 wearing an electronic device in the armpit that continuously measures body temperature.

(i) Suggest why using **method 1** alone is not likely to be a very reliable method of avoiding conception.

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.....[2]

(ii) Explain how **method 2** could be used to avoid conception.

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(iii) Suggest why **method 3** is likely to be a better predictor of ovulation than measuring basal temperature with a thermometer each day.

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.....[2]

For Examiner's Use

(d) A study was carried out into the timing of the fertile window. The study involved 221 women who were trying to get pregnant.

Urine samples from each woman were tested for LH breakdown products every day for several months. The women recorded the days on which they had sexual intercourse, and also the days on which menstruation began.

136 of the women became pregnant during the study.

The results were used to calculate the probability of a woman being in the fertile window on each day of her cycle. The results for women with regular 28-day cycles are shown in Fig. 4.2.

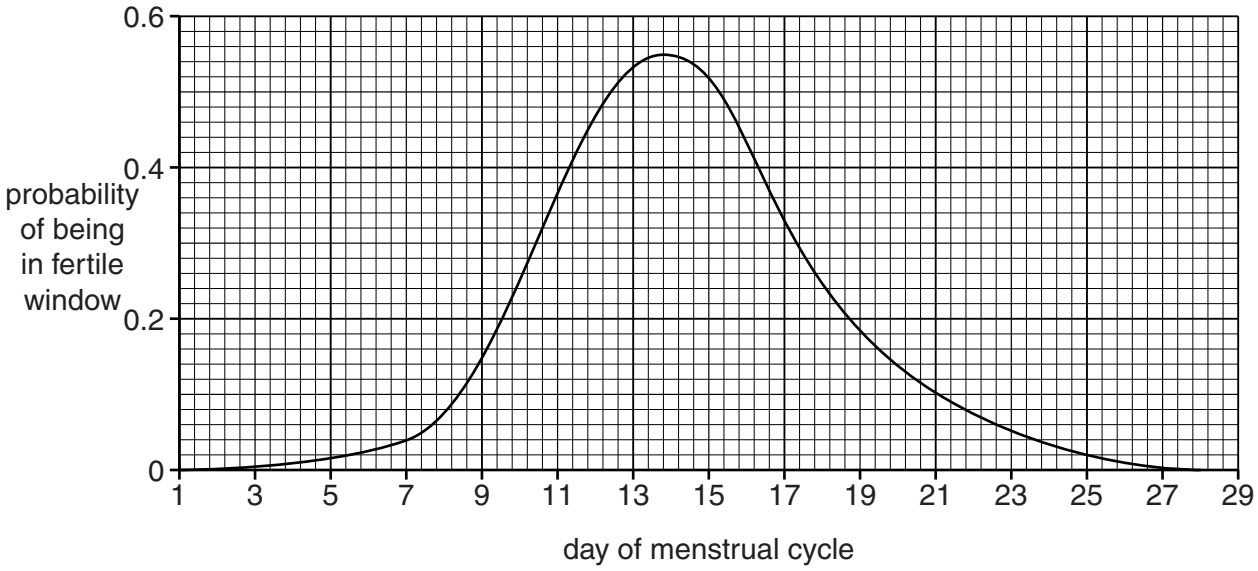


Fig. 4.2

Discuss what these results suggest about the guidelines that the fertile window lasts from day 10 to day 17 of the menstrual cycle.

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.....[4]

[Total: 15]

Question 5 starts on page 12

5 Maize was developed from a wild plant called teosinte, which grows from Mexico south to Argentina. It is thought that cultivated maize was derived from teosinte only once.

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Maize has been found at archaeological sites dated to 5500 years ago.

(a) Fig. 5.1 shows the genetic diversity at ten gene loci in teosinte and in cultivated maize. This was determined by sequencing the DNA base pairs at each locus, and calculating how much each of these base sequences varied. The gene loci are numbered in order of the degree of diversity in teosinte.

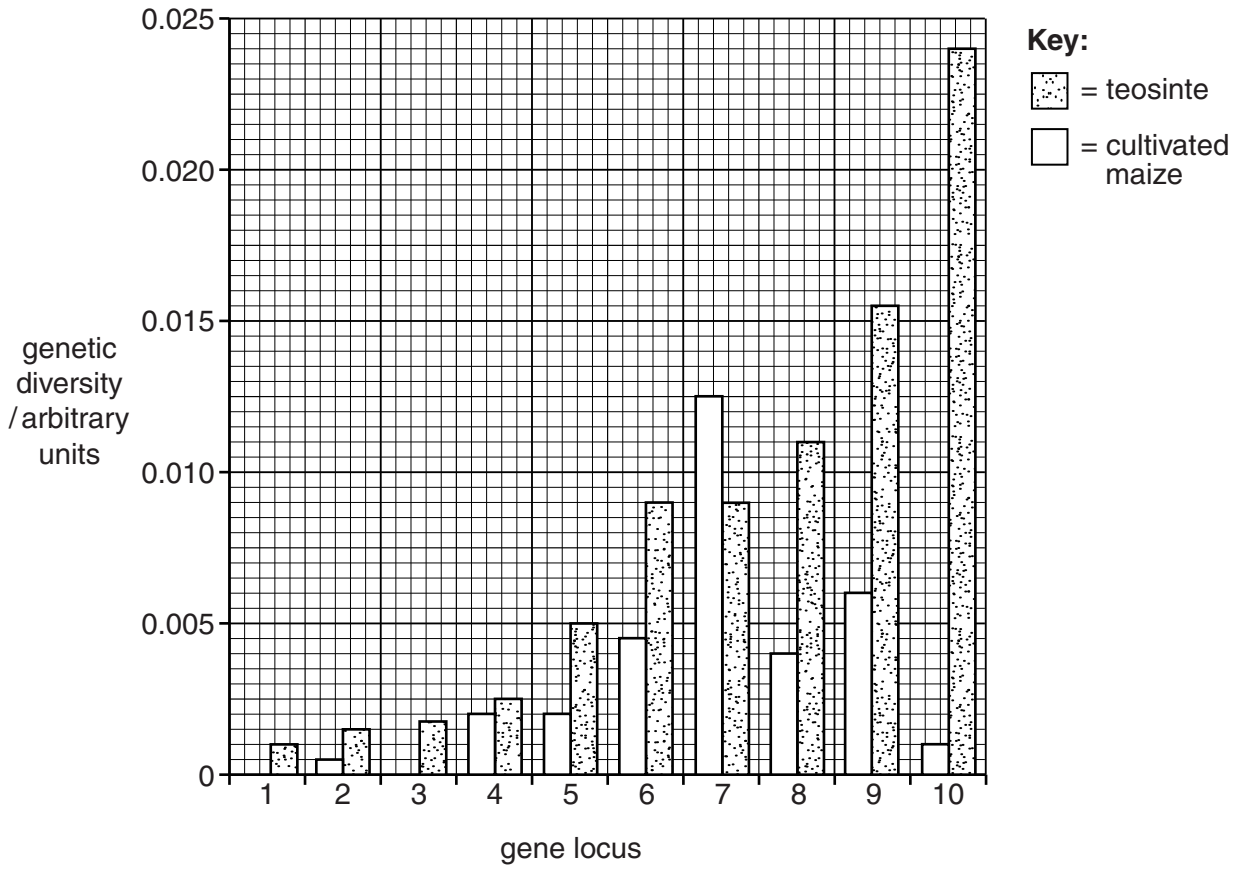


Fig. 5.1

(i) Compare the genetic diversity of teosinte with that of cultivated maize.

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.....[2]

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(ii) Suggest reasons for the differences in genetic diversity between teosinte and cultivated maize.

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.....[3]

(iii) Explain how these data support the idea that wild relatives of crop plants, such as maize, should be conserved.

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.....[2]

(b) Most farmers today grow maize from seeds that have been produced by crossing two different homozygous parents.

Explain why this is done.

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.....[3]

[Total: 10]

6 Fig. 6.1 is a trace that shows the changes that occur in the membrane potential of a neurone during an action potential.

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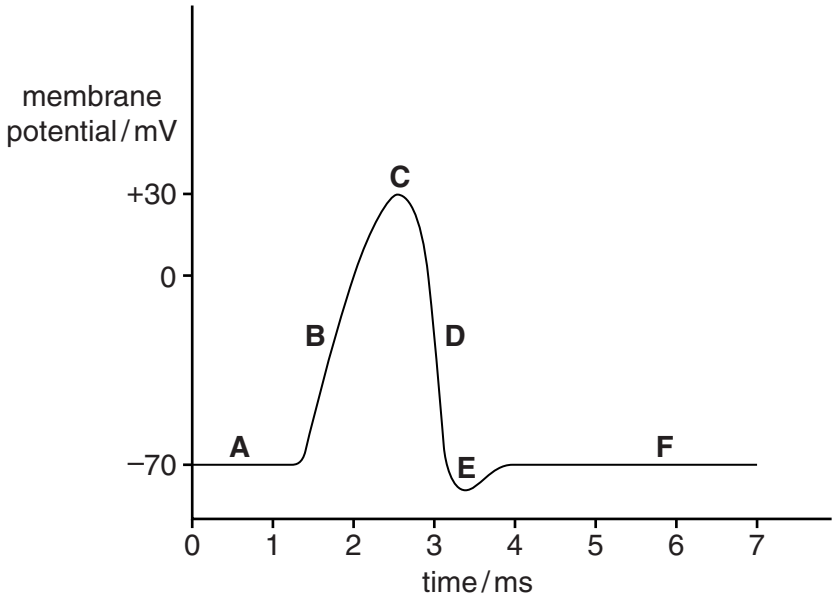


Fig. 6.1

(a) Using the letter(s) **A** to **F** from Fig. 6.1, state which letter(s) corresponds to the following:

(i) depolarisation .....

(ii) hyperpolarisation .....

(iii) the membrane is most permeable to potassium ions .....

(iv) resting potential ..... [4]

(b) Saxitoxin is a powerful poison produced naturally by single-celled, eukaryotic, photosynthetic, marine organisms. Shellfish may consume organisms containing saxitoxin but are unaffected. If humans were to eat shellfish containing saxitoxin they would become very ill and may die.

(i) State the kingdom to which the organisms that produce saxitoxin belong.

.....[1]

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(ii) Saxitoxin blocks sodium ion channels in the cell surface membranes of neurones.

Describe the role of sodium ion channels in the transmission of a nerve impulse.

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.....[3]

(iii) Suggest why saxitoxin may be fatal to humans.

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.....[2]

[Total: 10]

7 The light-dependent stage of photosynthesis takes place on the thylakoids of the chloroplast.

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Fig. 7.1 shows some of the components involved in the light-dependent stage.

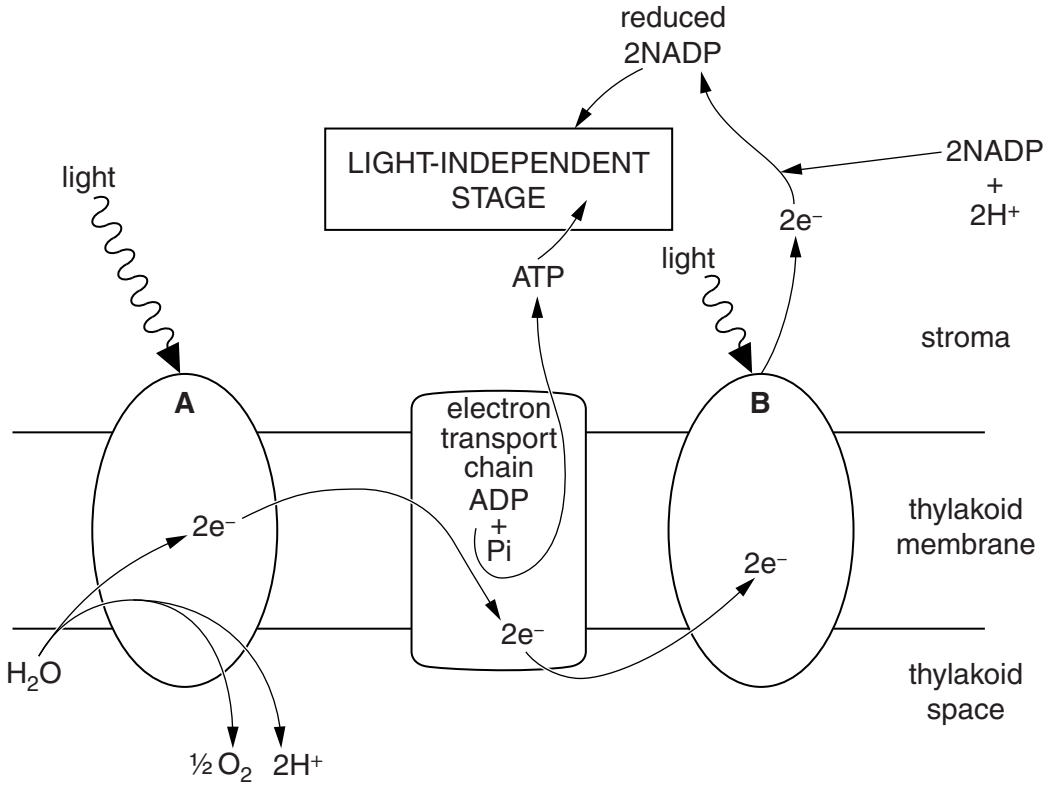


Fig. 7.1

(a) With reference to Fig. 7.1, identify structures **A** and **B**.

A .....

B .....[2]

(b) Describe the roles of the following substances in the light-independent stage of photosynthesis:

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(i) RuBP

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.....[2]

(ii) reduced NADP

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.....[2]

(iii) ATP.

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.....[2]

[Total: 8]

8 The Atlantic cod, *Gadus morhua*, is fished for food.

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(a) Fig. 8.1 shows the size of the stocks of Atlantic cod between 1968 and 2000.

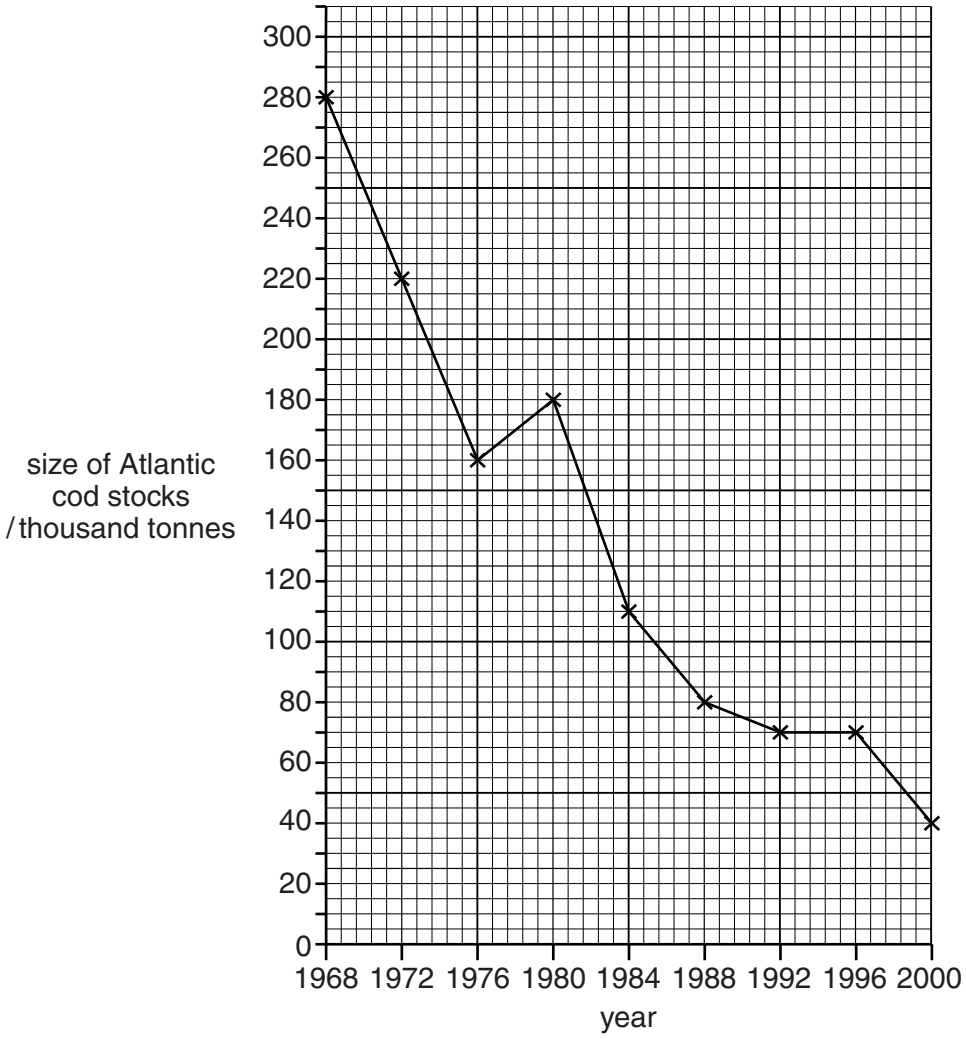


Fig. 8.1

Calculate the overall rate of decrease in size of the stocks of Atlantic cod between 1968 and 2000.

answer ..... tonnes per year [2]

(b) Suggest how the stocks of Atlantic cod may be increased.

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.....[3]

[Total: 5]

9 The passage below summarises the effects of auxin on the growth of a shoot.

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

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Auxin is synthesised in the growing tips of shoots (apical buds). It is transported from here down the shoot by …… from cell to cell and also to a lesser extent by …… flow in the …… .

Auxin seems to be involved in determining whether a plant grows upwards or whether it branches sideways. When the apical bud is actively growing, it tends to stop lateral buds from growing. This is called apical …… . The plant grows upwards rather than branching out sideways.

However, if the apical bud is cut off, the lateral buds start to grow. It is thought that removal of the apical bud causes the concentration of auxin in lateral buds to …… so the buds can now grow by cell …… and cell …… .

[Total: 7]

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Section B

Answer **one** question.

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10 (a) Cystic fibrosis (CF) is a genetic disease caused by an autosomal recessive allele. Gene therapy has been attempted to treat CF since 1993. Outline the basic principles of gene therapy for the treatment of CF. [8]

(b) Describe the role of a genetic counsellor in dealing with genetic diseases in humans and discuss the circumstances in which a couple might be referred to a genetic counsellor. [7]

[Total: 15]

11 (a) Describe the role of the hormone insulin in maintaining a constant blood glucose concentration. [6]

(b) The hormone human chorionic gonadotrophin (HCG) is produced by a woman in the early stages of pregnancy. Describe how a pregnancy test kit can detect the presence of HCG. [9]

[Total: 15]

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