UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9626476858

BIOLOGY **9700/43**

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 **21** printed pages and **3** lined pages.

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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]

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.

For Examiner's Use

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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(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]

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

For Examiner's Use

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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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[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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(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.

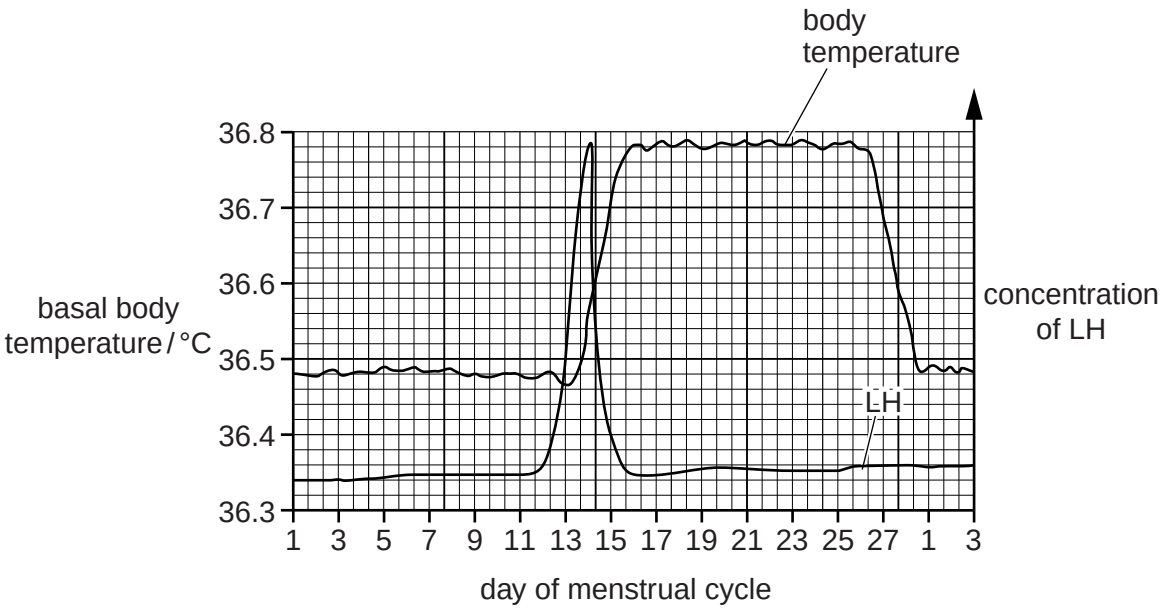


Fig. 4.1

(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]

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

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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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(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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(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.

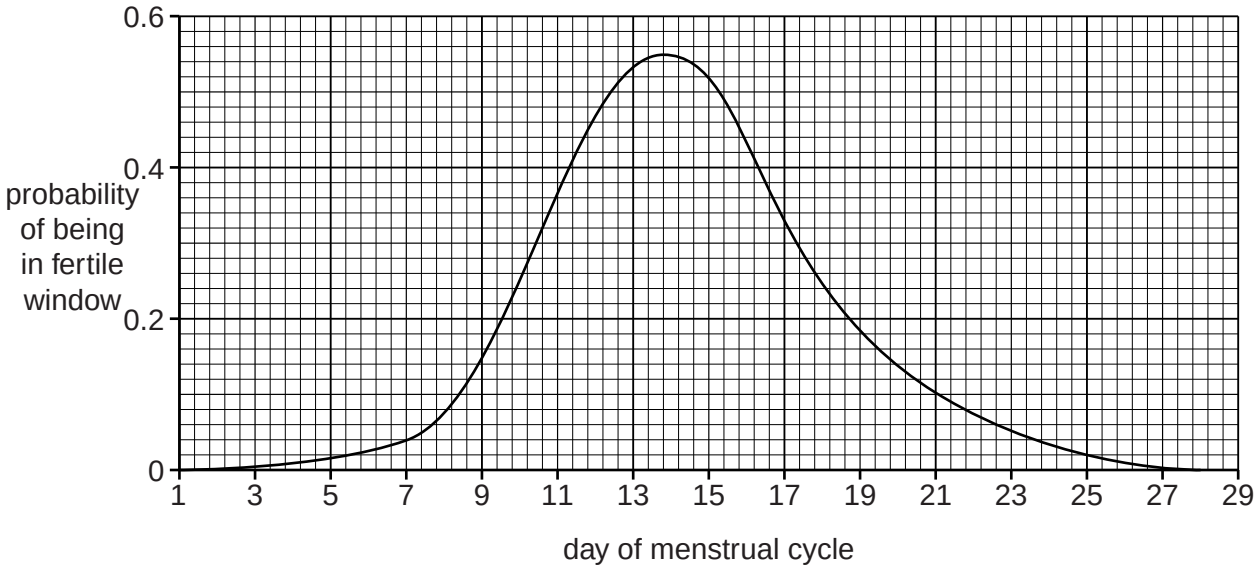


Fig. 4.2

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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[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.

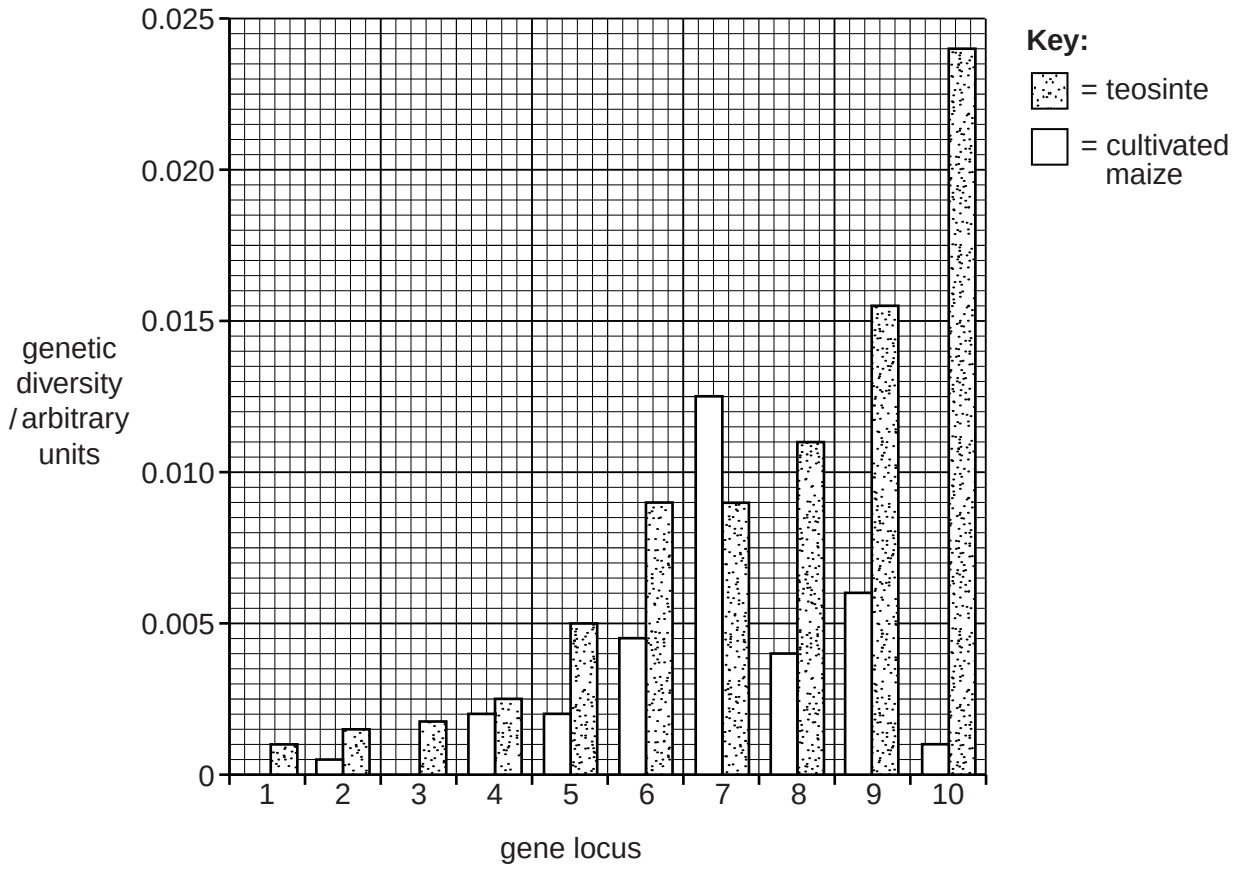


Fig. 5.1

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

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

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

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(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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[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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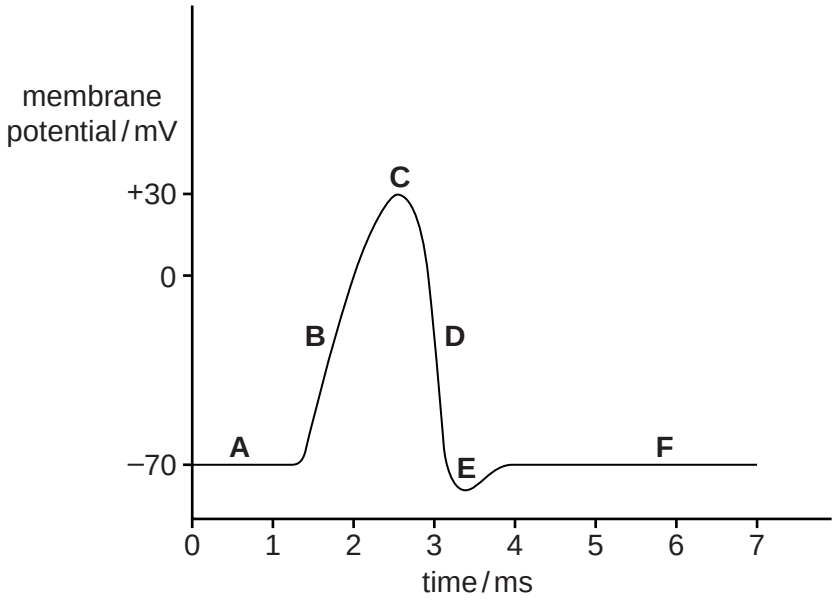


Fig. 6.1

(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.

For Examiner's Use

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

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[Total: 10]

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

For Examiner's Use

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

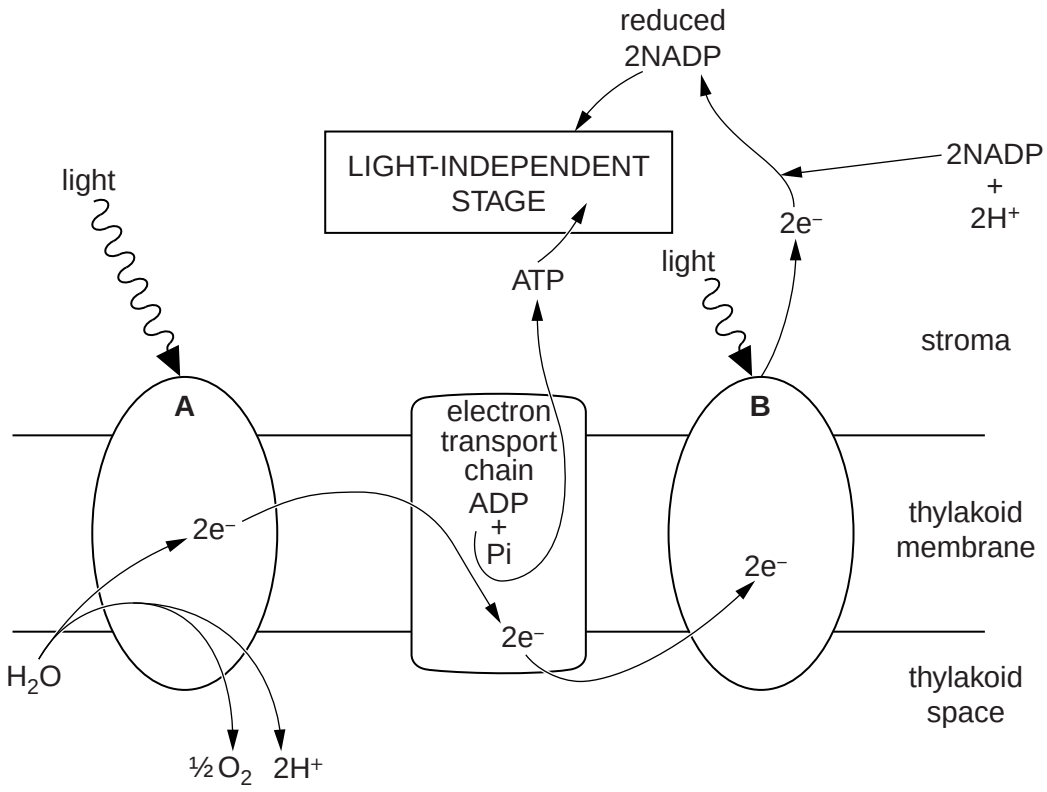


Fig. 7.1

(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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[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.

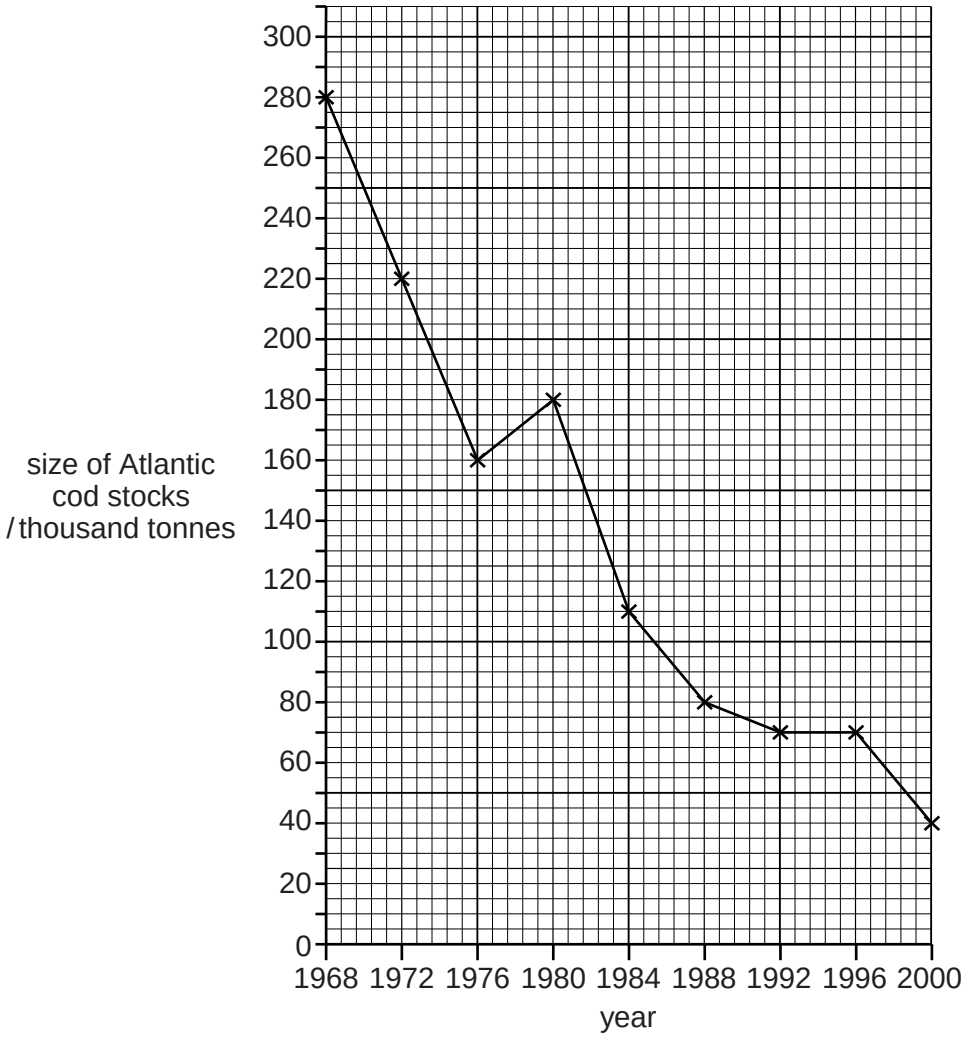


Fig. 8.1

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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[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]

Section B

For Examiner's Use

Answer **one** question.

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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