UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9790/04**

Paper 4 Practical **May/June 2012**

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed on the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **both** questions.
Write your answers in the spaces provided on the Question Paper.
You will be given only 35 minutes for each question.

Section B
Answer **all** questions.
Write your answers in the spaces provided on the Question Paper.

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.

For Examiner's Use	
1	
2	
3	
4	
5	
Total	

This document consists of **18** printed pages and **2** blank pages.

Section A

For Examiner's Use

Answer **all** the questions in the spaces provided.

1 You are reminded that you have only **35 minutes** for question 1.

You should read through the whole of this question carefully and then plan your use of the time to make sure that you finish all the work that you would like to do.

The fruit of the cotton plant, *Gossypium hirsutum*, contains seeds surrounded by fibres known as lint. During processing, the lint is separated from the seeds and made into cotton fibres. The lint may stick to the processing equipment if reducing sugars and non-reducing sugars are attached to it. The quantity of sugars present determines the stickiness of the lint. Some sugars come from the plant and some fall on the lint after egestion by aphids that feed on cotton plants.

You are provided with five beakers of water, **C1** to **C5**, in which different samples of lint have been soaking for 24 hours. The same volume of water and mass of lint was used in each beaker.

Plan and carry out a safe procedure to test the water in beakers **C1** to **C5** for the presence of any sugars. The hazards associated with any of the materials involved are clearly marked on the containers.

Use your results to deduce the stickiness of the lint samples that have been soaking in each beaker.

Record your results and conclusions in a suitable form in the space below and on page 3.

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[Total: 14]

2 You are reminded that you have only **35 minutes** for question 2.

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You should read through the whole of this question carefully and then plan your use of the time to make sure that you finish all the work that you would like to do.

T1 is a transverse section of the testis of a small mammal.

(a) Make a low power plan drawing of **T1** to show the arrangement of five seminiferous tubules and any tissues found between them. Individual cells should not be drawn.

Label your plan drawing.

[6]

(b) Use the eyepiece graticule and the stage micrometer to measure the diameter of each of the five seminiferous tubules that you have drawn.

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Identify each tubule by writing the letters **A** to **E** on your drawing.

Calculate the mean diameter of the seminiferous tubules and the standard deviation.

Calculate the standard deviation using the formula:

$$s = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}$$

Record your measurements and the results of your calculations in the space below.

mean diameter of seminiferous tubules = ...

standard deviation = ... [7]

(c) Sertoli cells, sometimes known as nurse cells, are large cells in the lining of the seminiferous tubules.

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Use the high power lens of your microscope to locate a Sertoli cell.

Make a labelled drawing to show **one** Sertoli cell and the cells immediately surrounding it.

[7]

[Total: 20]

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Section B

For Examiner's Use

Answer **all** the questions in the spaces provided.

You will have only **80 minutes** to spend on Section B.

3 The enzyme urease is a catalyst of the hydrolysis of urea in solution, forming ammonia and carbon dioxide, for example in the breakdown of urea in soils by microorganisms.

You are required to plan an investigation to compare the activity of urease free in solution and urease immobilised in alginate beads.

As the reaction proceeds, the ammonia released dissolves, causing the pH to increase.

You are provided with the following equipment which you may use or not in your plan, as you wish. You may **not** use any additional equipment in your plan.

- an unlimited supply of calcium alginate beads all of uniform size prepared with a 50 g dm^{-3} urease solution (you may call this immobilised urease)
- an unlimited volume of 50 g dm^{-3} urease solution (you may call this free urease)
- an unlimited volume of 1.0 mol dm^{-3} urea solution
- an unlimited volume of distilled water
- beakers and flasks of different sizes
- stop watch or electronic timer
- broad and narrow range pH papers and liquids with appropriate colour charts, pH probes and meters
- colorimeter and tubes/cuvettes
- thermometer
- thermostatically-controlled water baths
- graduated pipettes and pipette fillers
- filter funnels
- syringes
- glass rods for stirring
- test-tubes and boiling tubes
- test-tube racks

Your plan should

- include a clear statement of the hypothesis or prediction
- identify the key variables
- give full details and explanations of the procedures that you would adopt to ensure that the results are as precise and reliable as possible
- show how you would present and analyse your results
- include a brief risk assessment
- be written in clear scientific language.

You may include a diagram or diagrams in your plan.

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For Examiner's Use

For Examiner's Use

[Total: 16]

4 Fig. 4.1 shows a female hedge sparrow or dunnock, *Prunella modularis*, feeding its nestlings.

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Fig. 4.1

Dunnocks have several reproductive strategies and associated nestling feeding strategies:

- monogamy – one female with one male so that each female receives the help of one male all of the time (full time) in feeding the nestlings – category **1** in Table 4.1 (although the male may die before being able to help feed the nestlings – category **2**)
- polygyny – two or more females with one male so that each female receives a male's help in feeding the nestlings part of the time (part time) (category **3**)
- polyandry – one female is shared by two or more males so that each female receives the help of at least two males full time (category **4**)
- polygynandry – two or more females share two or more males so that each female receives the help of at least two males part time (category **5**)

The strategy employed in any one area depends on the way in which the territories of males and females overlap.

A study of the breeding success of these different strategies was carried out in the Botanic Gardens in Cambridge. Two of the ways used to measure breeding success were:

- the mass of each nestling six days after hatching
- the proportion of nestlings that died within six days of hatching

[Turn over

Table 4.1 shows the effects on reproductive success of the different reproductive strategies and includes the sex and number of adults feeding the nestlings.

Table 4.1

reproductive strategy	number of females feeding the nestlings	number of full time and part time males feeding the nestlings	reproductive and feeding strategy category	mean mass of nestlings at day 6 / g ± 1 standard deviation	proportion of nestlings that died within six days of hatching	number of nests studied
monogamy	1	1 full time	**1**	12.30 ± 1.76	0.30	45
monogamy (male died)	1	none	**2**	8.33 ± 3.21	0.86	7
polygyny	1	1 part time	**3**	10.96 ± 3.03	0.57	14
polyandry	1	at least 2 full time	**4**	14.06 ± 1.28	0.31	31
polygynandry	1	at least 2 part time	**5**	11.80 ± 2.45	0.39	33

(a) Summarise the data shown in Table 4.1. You may refer to each reproductive and feeding strategy by its number (**1** to **5**).

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A statistical analysis showed that the variables that had a significant effect on the **mass of nestlings** were the reproductive and feeding strategy and the number of adults feeding the nestlings.

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Table 4.2 shows the comparisons made between the different types of reproductive and feeding strategies (**1** to **5**) analysed using *t*-tests.

Table 4.2

reproductive and feeding strategies	value for *t*	degrees of freedom	significance, *p*
1 v **2**	2.222	50	< 0.05
1 v **3**	1.529	.....	.....
1 v **4**	5.042	74	<0.001
1 v **5**	0.990	76	not significant
4 v **5**	2.793	.....	.....

Table 4.3 shows critical values of *t* at different levels of significance and degrees of freedom.

Table 4.3

degrees of freedom	significance, *p*		
	0.05	**0.01**	**0.001**
30	2.04	2.75	3.03
35	2.03	2.72	3.00
40	2.02	2.70	2.97
45	2.01	2.69	2.95
50	2.01	2.68	2.94
55	2.00	2.67	2.92
60	2.00	2.66	2.91
65	2.00	2.65	2.91
70	1.99	2.65	2.90
75	1.99	2.64	2.89
80	1.99	2.64	2.89

(b) Complete Table 4.2 by stating, for strategies **1** v **3** and **4** v **5**,

- the degrees of freedom
- the significance

Write your answers in the spaces in Table 4.2. [2]

(c) Explain why the *t*-test was used to assess the effects of the strategies on the mass of the nestlings.

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(d) Suggest and explain the limitations of using the data shown in Table 4.1 as the basis for assessing the overall success of the different reproductive and nestling feeding strategies.

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[Total: 10]

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Question 5 starts on page 16

5 Some types of bacteria can grow on a medium containing only glucose and some mineral ions. This medium is known as minimal medium. Bacteria that are able to do this are known as wild type bacteria. Unlike wild type bacteria, nutritional mutants are bacteria that lack an active enzyme for the synthesis of a certain essential compound required for growth and therefore cannot grow on a minimal medium. For example, the *trp* mutant is not able to make the enzyme to synthesise the amino acid tryptophan and the *his* mutant cannot synthesise the amino acid histidine.

Wild type bacteria and five different mutant types of bacteria, **A** to **E**, were grown on five different media as shown in Table 5.1. The growth of bacterial colonies on each of the media is indicated by a plus (+) sign and lack of growth by a minus (–) sign.

Ampicillin is an antibiotic.

Table 5.1

bacteria	medium used				
	1 minimal medium	**2** minimal medium and ampicillin antibiotic	**3** minimal medium and histidine	**4** minimal medium and tryptophan	**5** lactose and mineral ions
wild type	+	–	+	+	+
type **A**	–	–	+	–	+
type **B**	–	–	–	+	+
type **C**	–	–	+	–	–
type **D**	–	–	–	–	–
type **E**	+	+	+	+	+

(a) (i) Suggest why mutant type **C** cannot grow on minimal medium.

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(ii) Suggest why type **E** can grow on all the media.

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Transformation occurs when bacteria take up DNA from their surroundings. Gene transfer also occurs during conjugation when the bacterial chromosome of the donor bacterium is replicated and then transferred through a conjugation tube to the recipient bacterium as shown in Fig. 5.1.

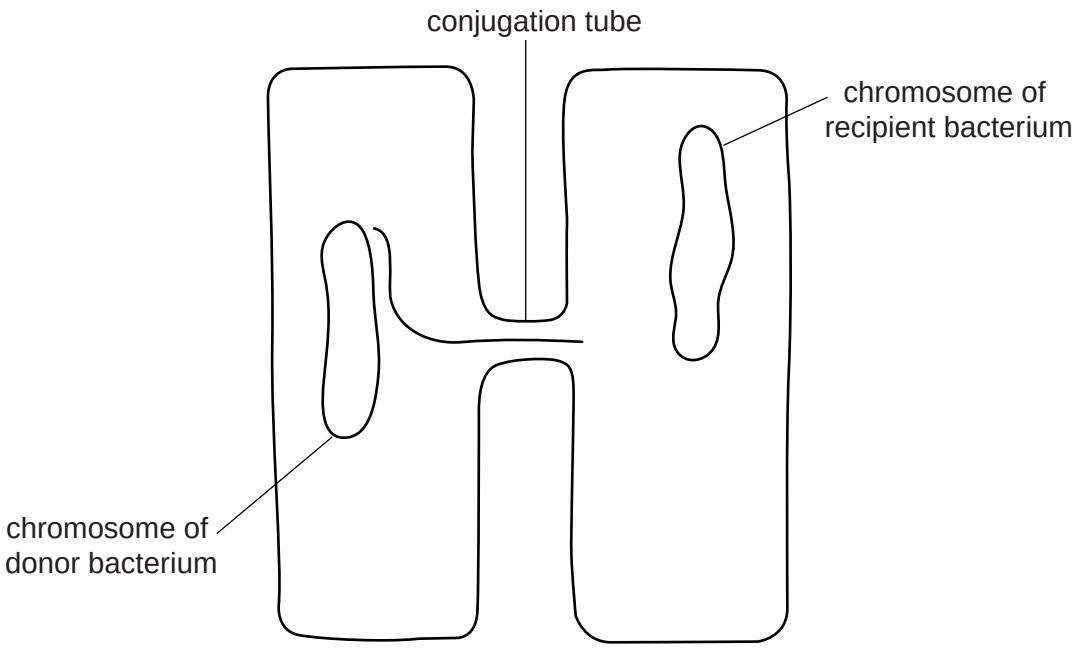

Fig. 5.1

The transfer of the whole chromosome to the recipient takes 60 minutes.

The order of genes on the chromosome and the distance between them can be determined by interrupting the transfer of the chromosome through the conjugation tube.

In an investigation of gene transfer, type **E** bacteria were used as the donor and type **D** as the recipient bacteria.

Samples were taken from the culture of the two types of bacteria at 10 minute intervals and shaken vigorously to break the conjugation tubes.

Small quantities of each sample were placed on media **2** to **5** as identified in Table 5.1.

The numbers of colonies of the recipient type **D** bacteria that developed from each sample are shown in Table 5.2. The time at which colonies begin to grow on a particular medium shows the time at which the appropriate gene was transferred from the wild type to the type **D** bacteria.

[Turn over

Table 5.2

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sampling time / minutes	numbers of colonies of recipient type **D** bacteria on the media			
	2	**3**	**4**	**5**
0	0	0	0	0
10	0	32	0	0
20	0	287	38	0
30	34	339	182	0
40	156	341	226	28
50	179	338	229	89
60	180	340	227	95

(b) (i) Plot the results from Table 5.2 on the graph paper provided. [3]

(ii) The time at which the genes are transferred is found by extrapolating the steepest parts of the lines to the x axis.

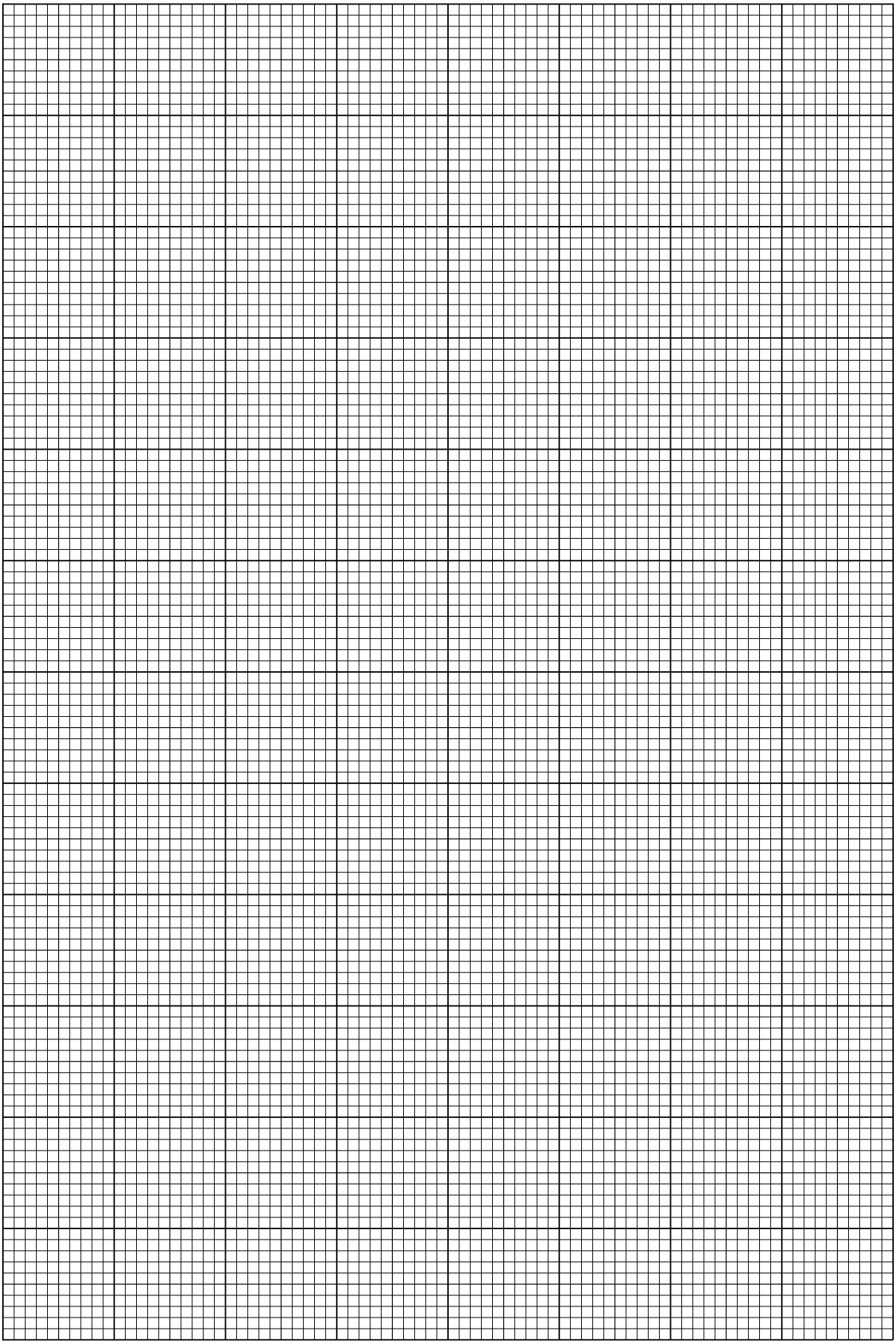
Use your graph to find the time when each gene is transferred and use Table 5.1 to identify the function of each gene.

Complete Table 5.3 by stating the function of each gene and giving the time when each gene is transferred.

Table 5.3

medium	function of each gene	time of gene transfer to recipient type **D** cells / minutes
2		
3		
4		
5		

[2]



For Examiner's Use

(c) Use the information from Table 5.3 to indicate the positions of the genes on the bacterial chromosome shown in Fig. 5.2.

For Examiner's Use

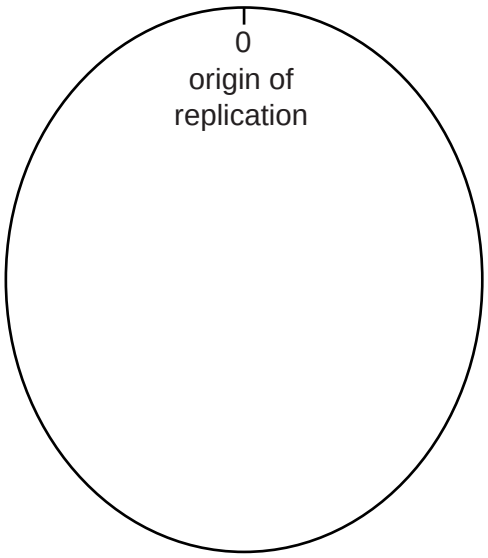


Fig. 5.2

[1]

[Total: 10]