The Cell

Question Paper 2

Level	Pre U
Subject	Biology
Exam Board	Cambridge International Examinations
Topic	The Cell
Booklet	Question Paper 2

Time Allowed: **60 minutes**

Score: **/50**

Percentage: **/100**

1 Maize plants have two genes, **A** / **a** and **B** / **b**, that are expressed in their pollen grains.

A = allele that gives pollen grains a yellow colour
a = allele that gives pollen grains a white colour

B = allele that gives non-waxy pollen grains
b = allele that gives waxy pollen grains

Assume that the two genes are **not** on the same chromosome.

Pollen was collected from the anthers of three plants that were heterozygous for both genes.

(a) State the genotype of the plants. ..... [1]

The pollen grains showed four different phenotypes. The number of pollen grains of each phenotype is shown in Table 5.1.

Table 5.1

	number of pollen grains of each phenotype			
	yellow non-waxy	yellow waxy	white non-waxy	white waxy
genotypes of pollen grains	.....	.....	.....	.....
plant 1	314	279	190	321
plant 2	324	420	513	432
plant 3	478	340	435	366
total	1116	1039	1138	1119

(b) Complete Table 5.1 by writing in the genotypes of the **pollen grains**. [2]

(c) The ratio of phenotypes **expected** in the pollen is 1:1:1:1.

The chi squared (χ^2) test is used to check whether or not the number of each phenotype is in agreement with the expected ratio.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Σ = sum of .....
O = observed value
E = expected value
degrees of freedom = number of classes – 1

Table 5.2

phenotypes	yellow non-waxy	yellow waxy	white non-waxy	white waxy
observed number (O)	1116	1039	1138	1119
expected number (E)	1103	1103	1103	1103
O – E	13	.....	35	16
$(O - E)^2$	169	.....	1225	256
$\frac{(O - E)^2}{E}$	0.15	.....	1.11	0.23

$\chi^2 = \sum \frac{(O - E)^2}{E}$	.....

(i) Complete Table 5.2 and calculate χ^2. [2]

(ii) State the null hypothesis for this investigation.

.....

..... [1]

(iii) State the number of degrees of freedom for this investigation.

..... [1]

Table 5.3

degrees of freedom	distribution of χ^2 probability, p						
	0.90	**0.50**	**0.10**	**0.05**	**0.02**	**0.01**	**0.001**
1	0.02	0.45	2.71	3.84	5.41	6.64	10.83
2	0.21	1.39	4.61	5.99	7.82	9.21	13.82
3	0.58	2.37	6.25	7.82	9.84	11.35	16.27
4	1.06	3.36	7.78	9.49	11.67	13.28	18.47

(iv) Using Table 5.3, state, with a reason, whether or not the calculated value for χ^2 supports the assumption that genes **A**/**a** and **B**/**b** are **not** on the same chromosome.

.....

.....

.....

..... [1]

[Total: 8]

2 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.

.....

.....

.....

..... [2]

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

.....

.....

.....

..... [2]

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.

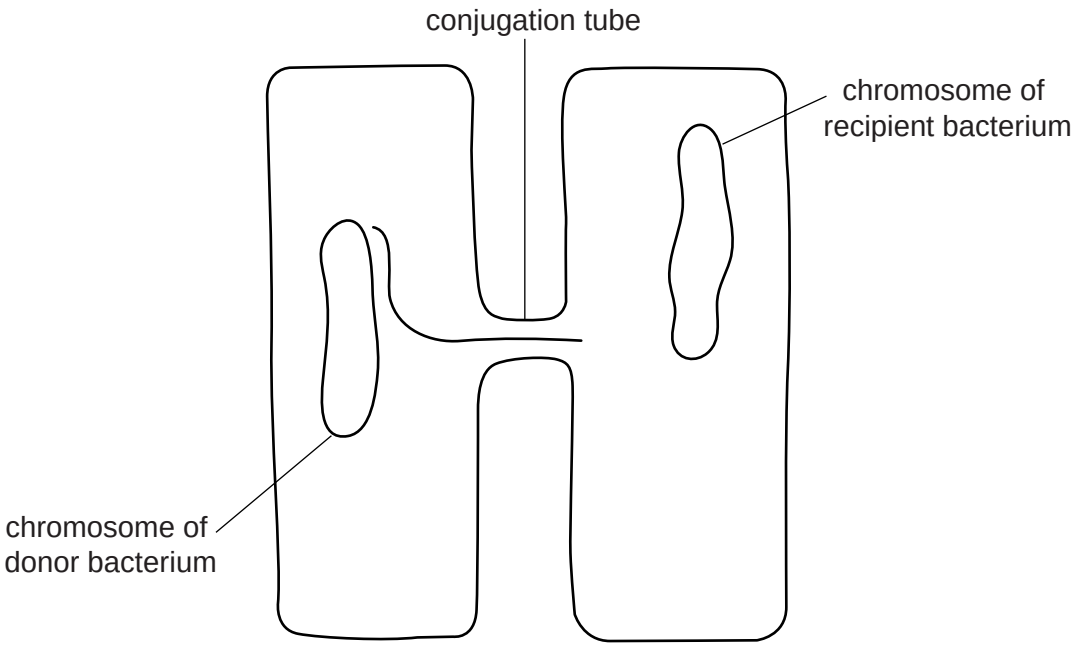


Fig. 5.1

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.

sampling time / minutes	numbers of colonies of recipient type **D** bacteria on the media			
	2	**3**		
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.

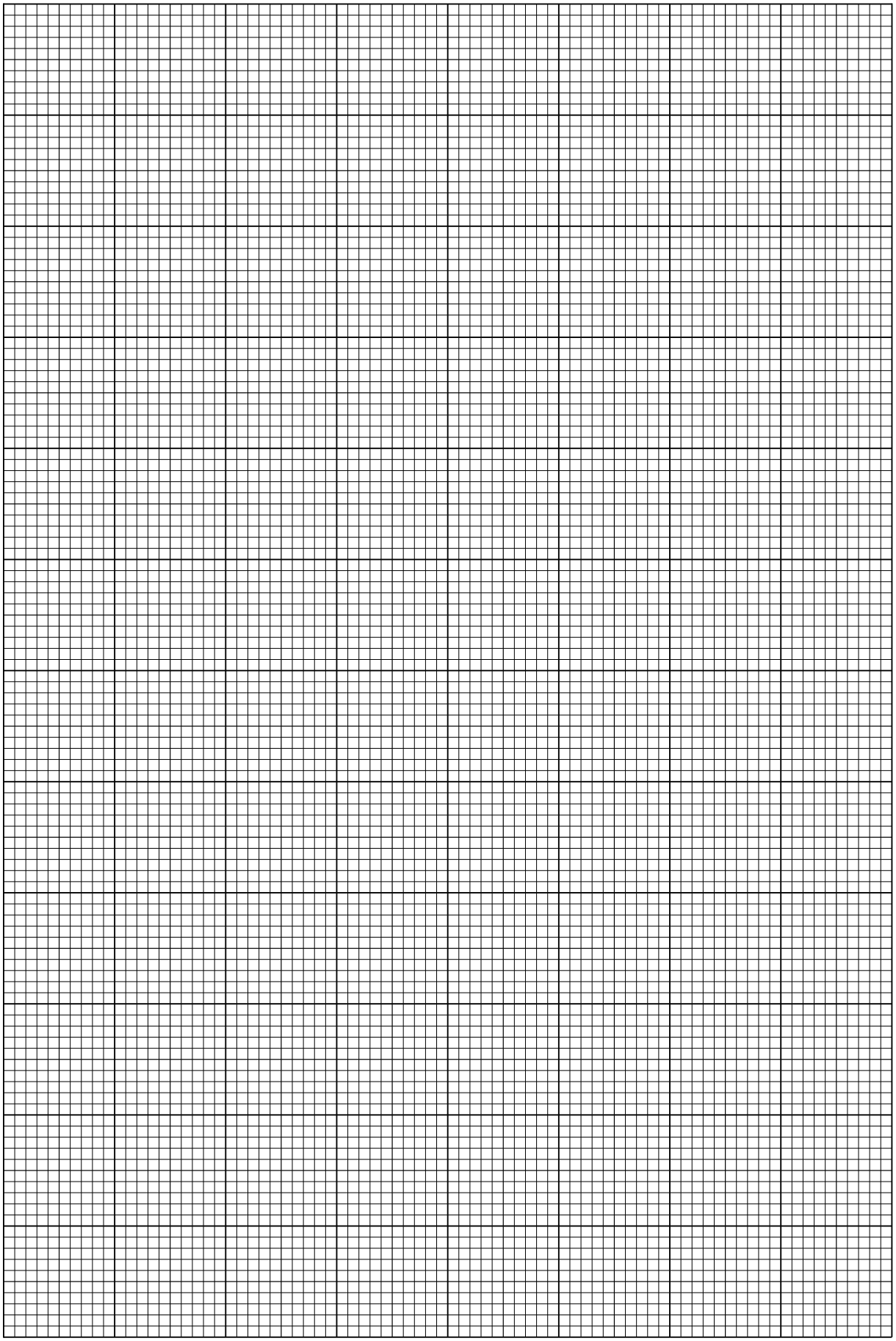
Use your graph to find the time when each gene is transferred and use Table 5.1 to identify the function of each gene.

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]



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

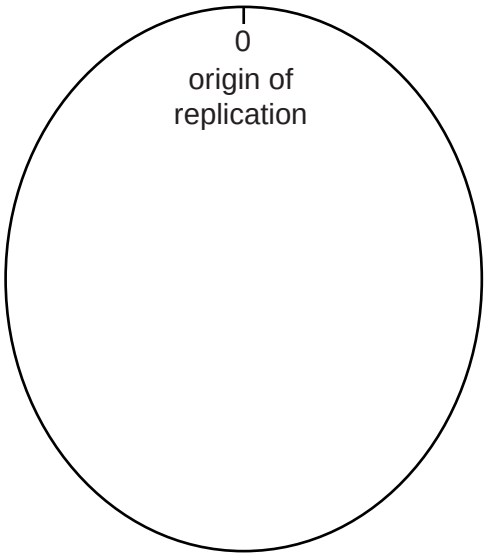


Fig. 5.2

[1]

[Total: 10]

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[Total: 16]

4 You are required to plan an investigation to determine how the respiratory quotients (RQs) of seeds with different storage substances change during germination.

Cereal grains, such as those of maize, wheat and barley, primarily store starch whereas mung beans store a mixture of substances, such as starch, lipid and protein.

The respiratory quotient of germinating seeds is influenced by

- the type of substances stored
- the type of respiration
- any interconversion between substances, e.g. lipid to carbohydrate.

A simple respirometer, such as that shown in Fig. 3.1, should be used in your plan.

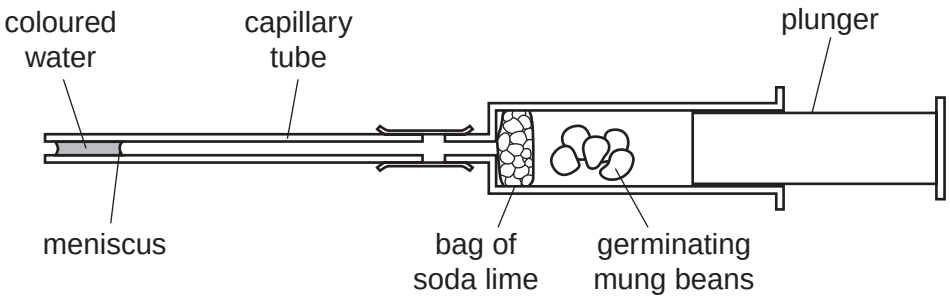


Fig. 3.1

The following equipment may be used in your plan or not as you wish. You may **not** use any additional equipment.

- maize, wheat or barley grains that have been soaked for 24 hours
- mung bean seeds that have been soaked for 24 hours
- small bags of soda lime
- an unlimited supply of syringes and lengths of capillary tubing to make simple respirometers as shown in Fig. 3.1
- beaker of coloured water
- thermometers
- an electronic top-pan balance accurate to 0.1 g (or 0.01 g)
- forceps
- temperature-controlled chamber
- stop watch or electronic timer
- a ruler marked in mm
- a marker pen

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
- include a brief risk assessment
- be written in clear scientific language.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[Total:16]