UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

2012066089 4

BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2012**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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 ink.
You may use a 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.

Answer **both** questions.

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.

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1	
2	
Total	

This document consists of **9** printed pages and **3** blank pages.

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1 A fresh water flowering plant grows on the surface of pond water. It occurs in large numbers on the surface of water polluted by sewage and fertilisers from agricultural land. Both of these pollutants contain high concentrations of nitrate and phosphate ions.

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The leaf-like photosynthetic tissue of the plant is called a thallus. Each plant has a single underwater root and a thallus which floats on the water. The plant reproduces asexually by buds that grow and split off to form separate plants.

Fig. 1.1 shows the appearance of three of these plants.

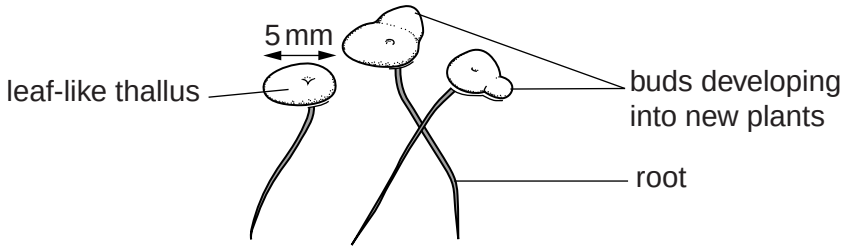


Fig. 1.1

A student investigated the effect of different concentrations of nitrate on the growth of the plant by counting the total number of the leaf-like thalli produced during a ten day period.

Fig. 1.2 shows seven thalli of different sizes and stages of development as seen from above.

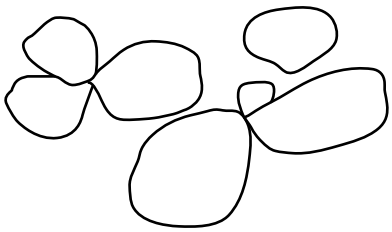


Fig. 1.2

The main stages in the procedure used by the student were:

1. Pond water was sterilised and used to make dilutions of sodium nitrate. A concentration of 4000 mg dm^{-3} was prepared and this was diluted to make the following concentrations:

   2000 mg dm^{-3}, 1000 mg dm^{-3}, 500 mg dm^{-3} and 250 mg dm^{-3}.

2. Plants were collected from a pond and those with a thallus without buds were selected.
3. The selected plants were surface sterilised with dilute bleach.
4. Each dilution of sodium nitrate was poured into a sterile glass dish and the dish covered with a lid.
5. Three surface-sterilised plants were placed in each of the dilutions of sodium nitrate and the lid replaced.
6. Four replicates of each sodium nitrate solution were set up in the same way.
7. All of the dishes were placed in a room at a constant temperature for 10 days.
8. The total number of leaf-like thalli in each dish was counted every day for 10 days.

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(a) (i) Identify the independent and dependent variables in this investigation.

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independent .....

dependent .....[1]

(ii) Identify **two** variables that the student controlled in this investigation.

.....[1]

(iii) There are other variables that the student could have controlled in this investigation.

Describe how **two other** variables could have been controlled.

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.....[4]

(b) (i) The student used the highest concentration (4000 mg dm^{-3}) to prepare the other concentrations of sodium nitrate.

Describe a procedure that the student used to prepare the other concentrations stated in stage 1. Your description should be sufficiently detailed so that another person can easily follow your procedure.

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.....[4]

(ii) The student also prepared another sterile glass dish to use as a control.

Suggest a suitable solution to use as a control for this investigation.

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.....[1]

(c) The results of the student's investigation are shown in Table 1.1.

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Table 1.1

concentration of sodium nitrate / mg dm^{-3}	mean number of thalli ± 1s at daily intervals									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
control	3	4±1	6±1	9±1	13±2	16±2	21±4	27±4	33±5	40±6
250	3	5±1	8±1	15±3	21±4	29±6	35±5	39±6	44±7	48±8
500	3	7±1	12±1	20±2	30±3	40±5	52±8	68±7	80±7	90±9
1000	3	9±1	18±2	30±3	45±3	65±6	90±8	120±10	158±13	180±12
2000	3	8±1	14±2	26±3	39±4	56±6	75±7	104±7	132±10	157±11
4000	3	8±1	11±1	22±2	33±5	48±6	60±6	88±8	106±9	135±10

(i) State what standard deviation (s) shows about the data.

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(ii) The results show that the standard deviation increased with time.

Suggest a reason for this increase.

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(d) State the conclusions that can be drawn from the results in Table 1.1 about the effect of different concentrations of nitrate on the growth of this plant.

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(e) Suggest how the student's investigation could be modified to find the optimum nitrate concentration for the growth of this plant.

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(f) Sewage and agricultural fertilisers contain phosphate as well as nitrate. In another investigation the student used sodium phosphate instead of sodium nitrate to test the effect of different concentrations of phosphate on the growth of the same plant.

Suggest a prediction that the student could make about the effect of different concentrations of phosphate on the growth of the plant.

Show your answer as a sketch graph on the axes below.



[2]

[Total: 20]

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2 Bacteria can be modified to produce human or animal proteins, such as insulin. The production of these proteins is more efficient if carried out by animal cells, such as rat tumour cells, maintained in culture.

An investigation was carried out to test the suitability of two systems for culturing rat tumour cells:

- batch culture in which the cells are mixed gently in the culture medium
- a form of continuous culture, known as a perfusion system, in which new culture medium is added to the cells and the old medium removed throughout the fermentation. The cells are kept in the system and are not removed.

During the investigation 20 samples were taken from each system at intervals of ten hours. Four factors were measured in each sample:

1. the number of cells in the culture medium
2. the survival of the cells in culture
3. the concentration of the nutrient, glucose
4. the concentration of the waste, lactic acid

Table 2.1 shows the results for factors 1 and 2.

Table 2.1

time / h	batch culture system		perfusion system	
	mean number of cells / millions of cells cm^{-3}	percentage cell survival	mean number of cells / millions of cells cm^{-3}	percentage cell survival
0	0.2	90	0.2	100
10	0.4	85	0.8	100
20	0.5	95	1.8	100
30	0.6	98	3.6	100
40	0.8	95	7.2	99
50	1.2	90	15.0	100
60	2.2	80	32.1	100

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Table 2.2 shows the results for factors 3 and 4.

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Table 2.2

time / h	batch culture system		perfusion system	
	concentration of glucose / mg cm^{-3}	concentration of lactic acid / mg cm^{-3}	concentration of glucose / mg cm^{-3}	concentration of lactic acid / mg cm^{-3}
0	4.2	0.1	2.1	0.2
10	4.0	0.2	2.5	0.5
20	3.8	0.5	2.8	0.9
30	3.5	1.2	2.0	1.4
40	2.1	1.8	1.9	1.3
50	1.5	2.6	2.2	0.8
60	1.0	3.1	2.2	1.1

(a) Outline how the number of cells may have been estimated.

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(b) Living cells may be identified by using a staining technique.

Suggest how the percentage of cell survival was calculated.

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.....[2]

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(c) A *t*-test was carried out to see if there is a significant difference between the number of cells in the two culture systems at 10 hours.

The value of **t = 2.62**

(i) State a null hypothesis for this test.

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.....[1]

(ii) State the number of degrees of freedom for this *t*-test.

.....[1]

Table 2.3 shows some probability values of *t*.

Table 2.3

degrees of freedom	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**40**	**50**	**60**
probability 0.05	2.23	2.18	2.14	2.12	2.10	2.09	2.07	2.06	2.06	2.05	2.04	2.02	2.01	2.00
probability 0.01	3.17	3.06	2.98	2.92	2.88	2.85	2.82	2.80	2.78	2.76	2.75	2.70	2.68	2.66

(iii) State what the value of *t* indicates about the difference in the number of cells in the two cultures systems at 10 hours.

.....[1]

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(d) The investigation showed that the perfusion system is a more efficient way to culture rat tumour cells.

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Describe how the data in Table 2.1 and Table 2.2 support the statement that the perfusion system is more efficient.

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[Total: 10]

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