Centre Number

71

Candidate Number

Rewarding Learning

ADVANCED
General Certificate of Education
2012

Biology

Assessment Unit A2 2

assessing

Biochemistry, Genetics and Evolutionary Trends

[AB221]

AB221

MONDAY 21 MAY, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Write your answers in the spaces provided in this question paper.
There is an extra lined page at the end of the paper if required.
Answer **all eight** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Section A carries 72 marks. Section B carries 18 marks.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You are reminded of the need for good English and clear presentation in your answers.
Use accurate scientific terminology in all answers.
You should spend approximately **25 minutes** on Section B.
You are expected to answer Section B in continuous prose.
Quality of written communication will be assessed in **Section B**, and awarded a maximum of 2 marks.
Statistics sheets are provided for use with this paper.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

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Section A

1 The terms ‘polygenic inheritance’ and ‘epistasis’ are used to describe particular patterns of inheritance.

State **one** way in which they are similar and then distinguish between the terms.

[3]

2 **(a)** Ferns (pteridophytes) show alternation of generations. The gametophyte stage (prothallus) is dependent on moisture as it does not have a cuticle or stomata. A moist environment is also necessary to facilitate sexual reproduction.

(i) Explain why sexual reproduction in ferns is moisture dependent.

____

____ [1]

If a female gamete (ovum) is fertilised, the dominant sporophyte stage develops. This stage has a waxy cuticle, stomata and vascular tissue and is therefore much less moisture dependent. However, due to the moisture-requiring gametophyte stage, ferns are normally restricted to damp environments.

The bracken fern (*Pteridium aquilinum*) is unusual among pteridophytes in that the sporophyte forms thick underground rhizomes (horizontal stems). Bracken is a very successful coloniser of mature sand dune systems, a habitat too dry for virtually all other ferns and even most flowering plants.

(ii) Suggest why bracken, unlike other ferns, is able to colonise the drier areas of sand dune systems.

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____ [2]

(iii) In sand dune systems, the bluebell (a traditional woodland species) frequently grows close to the bracken, rather than on more open ground.

Suggest **two** ways that the presence of bracken can facilitate bluebell growth in this habitat.

1. ____

____

2. ____

____ [2]

(b) Water availability also affects distribution in the kingdom Animalia. Species of the phylum Cnidaria are common in aquatic habitats but are not found in terrestrial habitats.

Give **two** reasons why Cnidarians are restricted to aquatic habitats.

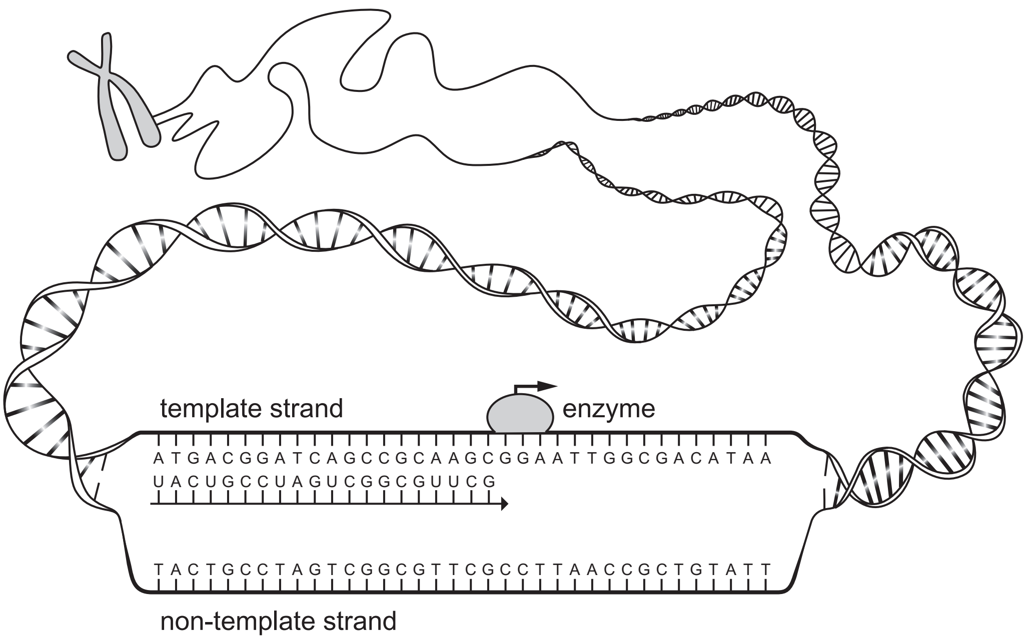
1. ____

____

2. ____

____ [2]

3 (a) The diagram below represents the process of transcription.



© CCEA A2 Biology Unit 2: Biochemistry, Genetics and Evolutionary Trends by John Campton, published by Philip Allan Updates, 2010. ISBN 978 1444112559

(i) Using the information provided, describe the process of transcription.

____

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____ [4]

(ii) Using **only** the information in the diagram, state **two** structural differences between DNA and RNA.

1. ____

____

2. ____

____ [2]

(b) It has long been known that genes are sections of chromosomes which control specific aspects of an organism's characteristics. Early research suggested that each gene coded for a protein or even for an enzyme: hence the '*one gene one protein*' and the '*one gene one enzyme*' hypotheses that were promoted several decades ago.

Current understanding of gene action suggests that the '*one gene one polypeptide*' hypothesis is a more accurate description.

(i) Using your understanding of protein structure, suggest why the '*one gene one polypeptide*' hypothesis is a more accurate description than each of the two earlier hypotheses.

____

____

____

____

____ [2]

(ii) Explain precisely what is meant by the term '*one gene one polypeptide*'.

____

____ [1]

(c) DNA length is measured in base pairs. Analysis of a particular polypeptide shows that the gene involved in its synthesis is 330 base pairs long yet the polypeptide itself has only 84 amino acids in its primary sequence.

(i) How many base pairs would be required to code for 84 amino acids?

_______________ [1]

(ii) Suggest why the gene contains 330 base pairs.

____

_______________ [1]

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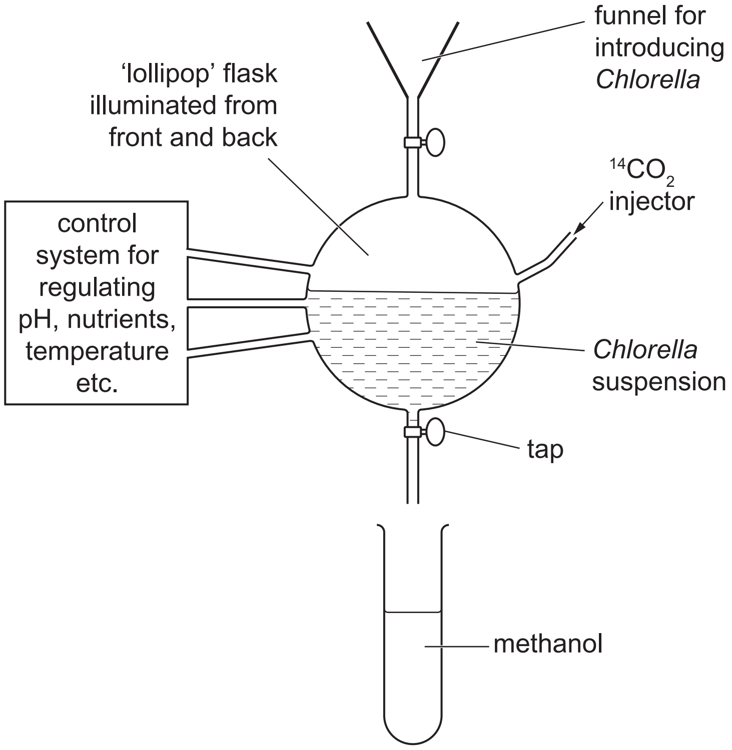
(Questions continue overleaf)

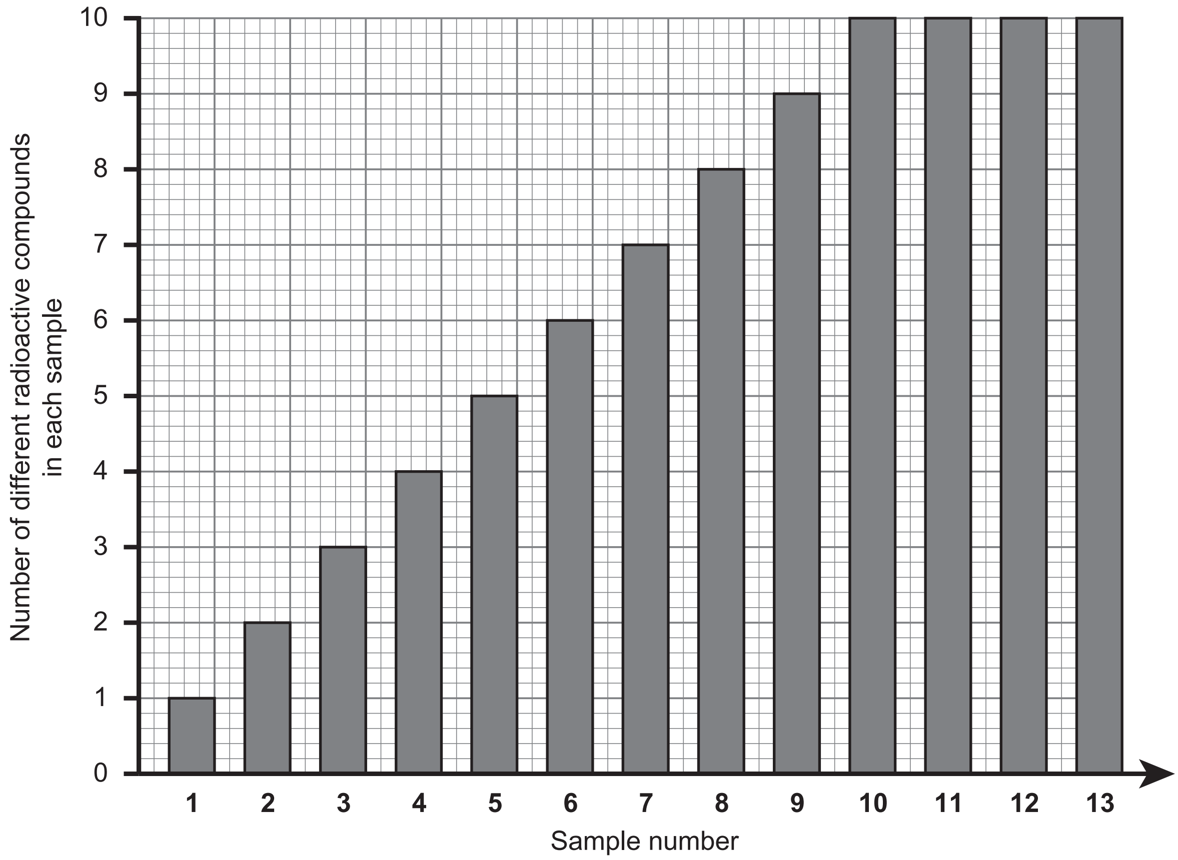
4 (a) The diagram below shows the apparatus used by Melvin Calvin to identify the steps in the light-independent stage of photosynthesis.



Calvin added radioactive carbon dioxide ($^{14}CO_2$) to the apparatus and, after a very short period of time, he opened the tap to release the *Chlorella* (an autotrophic protoctistan) into the methanol. This killed the *Chlorella* immediately and stopped any further reactions. The *Chlorella* was homogenised and the compounds present were identified by chromatography.

By gradually increasing the time interval between adding the radioactive carbon dioxide and killing the *Chlorella*, Calvin observed that the number of different compounds containing radioactive carbon in each successive sample increased up to a limit and then levelled off.

The bar chart below summarises the results for thirteen consecutive samples.



(i) Using your understanding of the light-independent stage, identify the first compound (in sample **1**) that contained radioactive carbon.

____ [1]

(ii) The number of radioactive compounds increases with time up to a point and subsequently levels off. Explain why.

____

____

____

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____ [2]

(iii) The time that the *Chlorella* was exposed to radioactive carbon dioxide was increased by only a few seconds for consecutive samples. Suggest why.

____

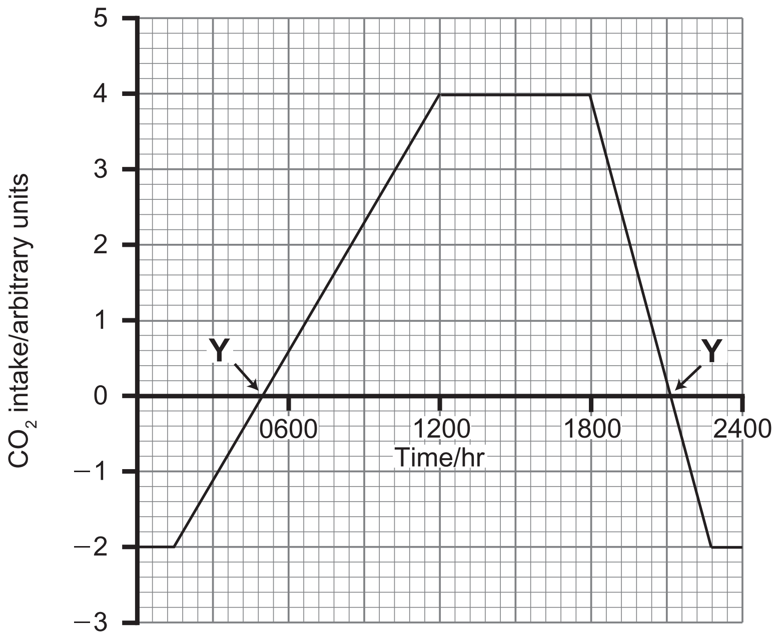
____ [1]

(iv) Suggest why Calvin used a specially flattened ('lollipop') flask in this investigation.

____

____ [1]

(b) The graph below shows the rates of carbon dioxide intake by a commercial crop plant in a glasshouse over a 24-hour period.



(i) State the term which is used to describe the situation indicated by the positions labelled **Y**.

____ [1]

(ii) The graph provides information on changes in the rate of net photosynthesis in the plant as opposed to gross photosynthesis. State the evidence for this.

[2]

(iii) The glasshouse does not have artificial lighting. Explain why it would be economically undesirable to artificially increase the temperature throughout the 24-hour period but potentially beneficial to increase the temperature between 12 noon and 6 pm.

[4]

5 Bacterial plasmids may carry genes that provide resistance to naturally occurring antibiotics.

(a) (i) What is a plasmid?

____

____ [1]

(ii) In recombinant DNA technology, plasmids are often used as vectors. Explain what is meant by the term 'vector' in this context.

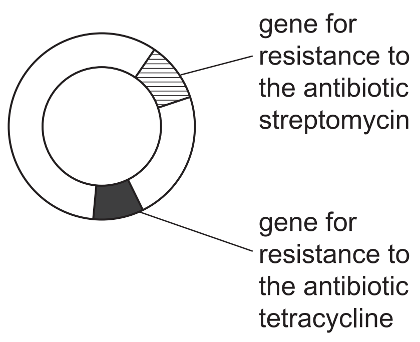
____

____ [1]

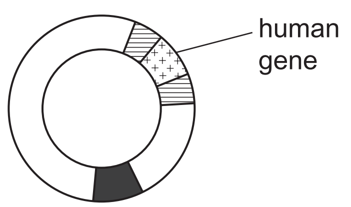
Diagram 1 illustrates a naturally occurring plasmid that contains genes for resistance to two antibiotics. When this plasmid is not present in a particular bacterium, the bacterium would be killed in the presence of either of these antibiotics.

Diagram 2 illustrates a recombinant plasmid, which has had a human gene inserted at the point shown.

1.



2.



(b) (i) Describe **two** methods by which a specific gene could have been obtained from human cells.

1. ______________________________

2. ______________________________ [4]

(ii) Describe how the human gene could then have been inserted into the original plasmid **(diagram 1)** to produce the recombinant plasmid **(diagram 2)**.

______________________________ [3]

The human gene, referred to previously, codes for the production of a medically important hormone. In order to mass produce the hormone, *E. coli* cells (lacking any plasmids providing antibiotic resistance) are encouraged to take up plasmids. Those *E. coli* cells which have taken up the recombinant plasmids are identified and cloned in a nutrient medium and the hormone then separated and purified.

(c) **(i)** Explain how the *E. coli* bacteria might be encouraged to take up the recombinant plasmids.

____

____ [1]

(ii) Outline the procedure by which the bacteria that have taken up the recombinant plasmid (**diagram 2**), might be identified.

____

____

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____

____

____ [2]

(iii) Explain how the elimination of other bacteria would increase the efficiency of the production of hormone.

____

____ [1]

Using bacteria to manufacture hormones has many advantages. For example, an increasing number of people with diabetes has increased the demand for the hormone insulin. This increased demand is met by producing insulin from genetically modified bacteria rather than extraction from the pancreas of cattle or pigs.

(d) Suggest **one** health and **one** ethical advantage of using bacteria to produce insulin.

Health advantage ____

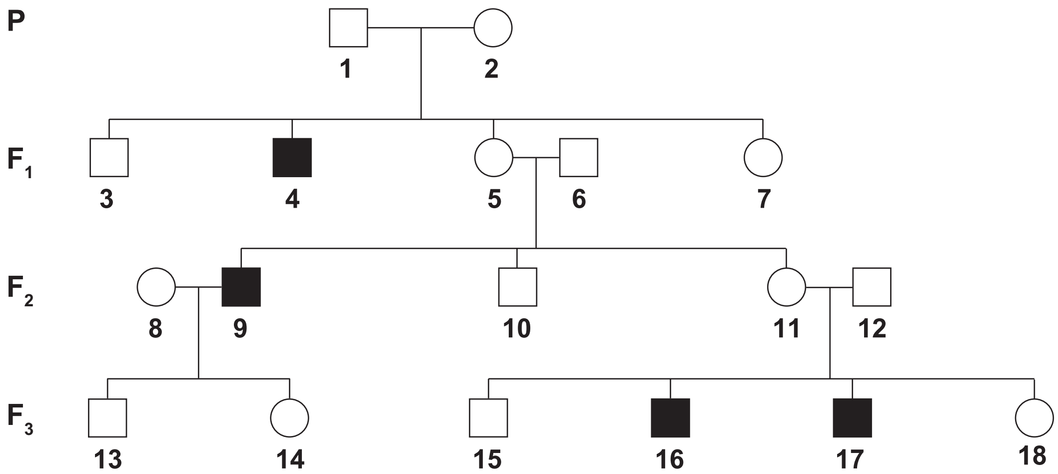
____

Ethical advantage ____

____ [2]

6 Haemophiliacs possess a non-functional form of the gene responsible for the production of blood clotting factors.

The pedigree diagram below shows the incidence of haemophilia in an affected family.



Individuals within the pedigree are numbered. Males are represented by squares and females by circles. Those who have haemophilia are represented by solid symbols.

(a) On the basis of the information provided, is the inheritance of haemophilia:

(i) autosomal or sex-linked? ______________________________

Justify your answer ______________________________

____

______________________________ [1]

(ii) dominant or recessive? ______________________________

Justify your answer ______________________________

____

______________________________ [1]

(b) Using the symbols **h** to represent the allele for haemophilia and **H** for the normal allele, state the genotype of each of the following:

- individual **2** ______________________________
- individual **4** ______________________________ [2]

(c) Individual **14** carries a recessive allele for albinism (lack of normal body pigment) which is not sex-linked. She marries a man who is also a carrier for albinism but who does not carry the haemophilia allele. The genes exhibit independent inheritance.

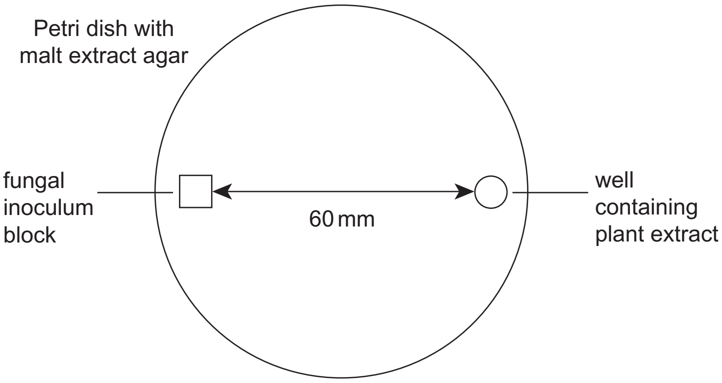
Using the symbol **a** for albinism and **A** for normal pigmentation, show, by means of a suitable genetic diagram, the probability of this couple producing a male child who has both haemophilia and albinism.

[5]

(d) There is no evidence of haemophilia in previous generations of this family. State the most likely reason for the condition appearing in the family pedigree shown.

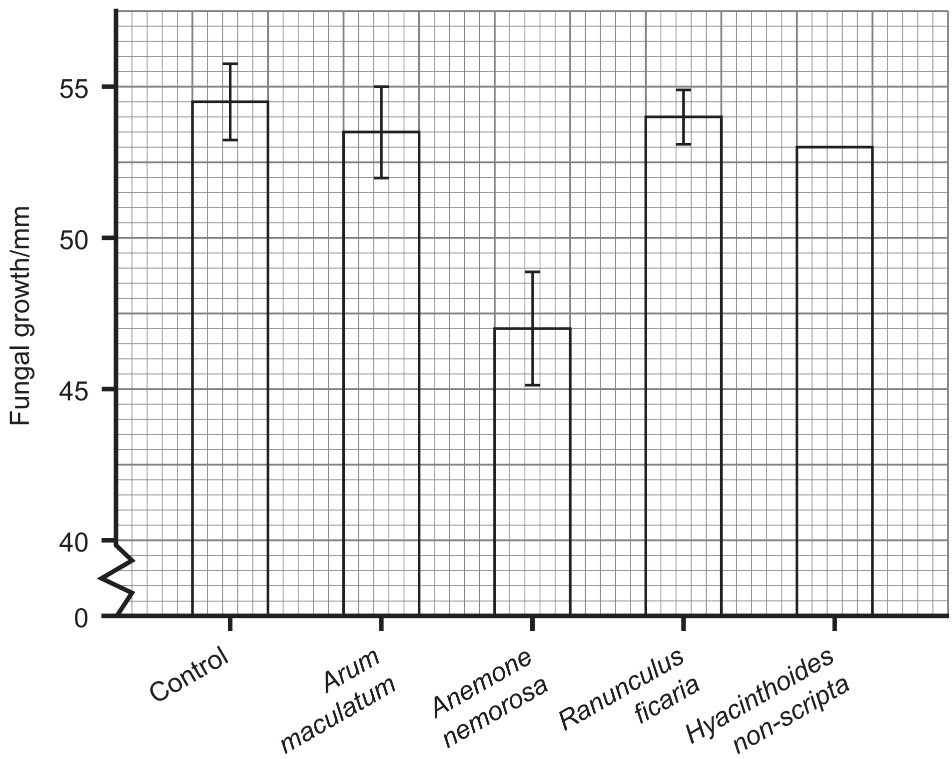
______________________________ [1]

7 Many plant species possess natural fungicides that help protect against infection. An investigation was set up to compare the anti-fungal properties of four species: *Hyacinthoides non-scripta* (bluebell), *Ranunculus ficaria* (lesser celandine), *Arum maculatum* (cuckoo pint), and *Anemone nemorosa* (wood anemone). Petri dishes, containing malt agar, were prepared. Each dish was inoculated with the fungus *Phythium debaryanum* opposite an extract of one of the plant species as shown below.



The plant extracts were prepared by grinding 5 g of fresh plant tissue in 2 cm^3 of cooled boiled water. Ten replica plates were produced for each plant species and the plates were incubated at 25 °C. Following inoculation of the test plates, fungal growth was measured and recorded every 24 hours. Fungal growth was taken as the distance from the edge of the inoculum block to the colony edge, measured as the extent of growth out from the inoculum block towards the plant extract well opposite.

The bar chart below shows the mean fungal growth after 4 days for extracts of plant species and also for a control. 95% confidence limits are also shown except for *H. non-scripta*.



(a) Suggest a suitable control for this investigation.

____ [1]

(b) The mean growth value for bluebell (*H. non-scripta*) after four days was 53 mm and the standard deviation (error) of the mean was 0.442.

(i) Using the information provided and your Statistics sheets, calculate the 95% confidence limits for *H. non-scripta*.

upper limit ______________________

lower limit ______________________ [3]

(ii) Complete the graph provided by adding the 95% confidence limits for *H. non-scripta*. [1]

(iii) The null hypothesis for this investigation stated that there was no significant difference between the effects of each of the plant extracts on the growth of the fungus. Based on the information provided, state your decision about the null hypothesis. Explain your answer.

____

____

____

____ [2]

The plant species involved in this investigation are woodland species which grow and make use of the high light levels in spring before the tree canopy closes. During summer their leaves die and are decomposed, a process that enriches soil fertility. The anti-fungal effect of plant tissue is greatest in early spring as the delicate leaves emerge through the soil, but is significantly reduced by the summer following the closure of the tree canopy.

(c) Explain the advantage to the plants of the pattern of anti-fungal activity described above.

[2]

(d) Earthworm activity is usually integral to the decay process in woodlands.

Earthworms are detritivores. They drag leaf material into their extensive network of burrows in the soil. In due course, they deposit the broken up and partially digested leaf material as worm casts throughout the soil. The presence of a large population of earthworms has proved to be very effective in promoting the processes of decomposition and nutrient (including nitrogen) recycling.

(i) To which phylum does the earthworm belong?

______________________________ [1]

(ii) Suggest how the presence of a large earthworm population, and their network of burrows, can significantly promote the processes involved in the recycling of nitrogen.

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______________________________ [4]

Section B

Quality of written communication is awarded a maximum of 2 marks in this section.

8 There are similarities and differences in the way ATP is synthesised in respiration and photosynthesis.

(a) Give an account of the synthesis of ATP in both respiration and photosynthesis. [11]

(b) Discuss the similarities and differences between the two processes. [5]

Quality of written communication [2]

(a) Give an account of the synthesis of ATP in both respiration and photosynthesis.

r Only

mark

r Only
mark

(b) Discuss the similarities and differences between the two processes.

Extra lined page

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER

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Biology

Statistical Formulae and Tables

Statistics Sheets

Statistical Formulae and Tables

1 Definition of Symbols

n = sample size

$\bar{x}$ = sample mean

$\hat{\sigma}$ = estimate of the standard deviation

These parameters are obtained using a calculator with statistical functions, remembering to use the function for $\hat{\sigma}$ – which may be designated a different symbol on the calculator – with (n – 1) denominator.

2 Practical Formulae

2.1 *Estimation of the standard deviation (error) of the mean* $(\hat{\sigma}_{\bar{x}})$

$$\hat{\sigma}_{\bar{x}} = \sqrt{\frac{\hat{\sigma}^2}{n}}$$

2.2 *Confidence limits for population mean*

$$\bar{x} \pm t\sqrt{\frac{\hat{\sigma}^2}{n}}$$

which can be rewritten, in terms of $\hat{\sigma}_{\bar{x}}$, as

$$\bar{x} \pm t(\hat{\sigma}_{\bar{x}})$$

where t is taken from t tables for the appropriate probability and n – 1 degrees of freedom.

3 Tests of significance

3.1 *Student's t test*

Different samples are denoted by subscripts; thus, for example, $\bar{x}_1$ and $\bar{x}_2$ are the sample means of sample 1 and sample 2 respectively.

The following formula for t is that to be used:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\dfrac{\hat{\sigma}_1^{\,2}}{n_1} + \dfrac{\hat{\sigma}_2^{\,2}}{n_2}}}$$

which can be rewritten, in terms of $\hat{\sigma}_{\bar{x}}$, as

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\hat{\sigma}_{\bar{x}_1}^{\;2} + \hat{\sigma}_{\bar{x}_2}^{\;2}}}$$

with $n_1 + n_2 - 2$ degrees of freedom.

3.2 *Chi squared test*

Using the symbols O = observed frequency, E = expected frequency and Σ = the sum of

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

with $n - 1$ degrees of freedom (where n is the number of categories).

Table 1 Student's *t* values

d.f.	*p* = 0.1	0.05	0.02	0.01	0.002	0.001
1	6.314	12.706	31.821	63.657	318.31	636.62
2	2.920	4.303	6.965	9.925	22.327	31.598
3	2.353	3.182	4.541	5.841	10.214	12.924
4	2.132	2.776	3.747	4.604	7.173	8.610
5	2.015	2.571	3.365	4.032	5.893	6.869
6	1.943	2.447	3.143	3.707	5.208	5.959
7	1.895	2.365	2.998	3.499	4.785	5.408
8	1.860	2.306	2.896	3.355	4.501	5.041
9	1.833	2.262	2.821	3.250	4.297	4.781
10	1.812	2.228	2.764	3.169	4.144	4.587
11	1.796	2.201	2.718	3.106	4.025	4.437
12	1.782	2.179	2.681	3.055	3.930	4.318
13	1.771	2.160	2.650	3.012	3.852	4.221
14	1.761	2.145	2.624	2.977	3.787	4.140
15	1.753	2.131	2.602	2.947	3.733	4.073
16	1.746	2.120	2.583	2.921	3.686	4.015
17	1.740	2.110	2.567	2.898	3.646	3.965
18	1.734	2.101	2.552	2.878	3.610	3.922
19	1.729	2.093	2.539	2.861	3.579	3.883
20	1.725	2.086	2.528	2.845	3.552	3.850
21	1.721	2.080	2.518	2.831	3.527	3.819
22	1.717	2.074	2.508	2.819	3.505	3.792
23	1.714	2.069	2.500	2.807	3.485	3.767
24	1.711	2.064	2.492	2.797	3.467	3.745
25	1.708	2.060	2.485	2.787	3.450	3.725
26	1.706	2.056	2.479	2.779	3.435	3.707
27	1.703	2.052	2.473	2.771	3.421	3.690
28	1.701	2.048	2.467	2.763	3.408	3.674
29	1.699	2.045	2.462	2.756	3.396	3.659
30	1.697	2.042	2.457	2.750	3.385	3.646
40	1.684	2.021	2.423	2.704	3.307	3.551
60	1.671	2.000	2.390	2.660	3.232	3.460
120	1.658	1.980	2.358	2.617	3.160	3.373
∞	1.645	1.960	2.326	2.576	3.090	3.291

Reproduced from R E Parker: "Introductory Statistics for Biology", Second Edition Studies in Biology No 43, Edward Arnold (Publishers) Ltd

Table 2 χ^2 values

d.f.	*p* = 0.900	0.500	0.100	0.050	0.010	0.001
1	0.016	0.455	2.71	3.84	6.63	10.83
2	0.211	1.39	4.61	5.99	9.21	13.82
3	0.584	2.37	6.25	7.81	11.34	16.27
4	1.06	3.36	7.78	9.49	13.28	18.47
5	1.61	4.35	9.24	11.07	15.09	20.52
6	2.20	5.35	10.64	12.59	16.81	22.46
7	2.83	6.35	12.02	14.07	18.48	24.32
8	3.49	7.34	13.36	15.51	20.09	26.13
9	4.17	8.34	14.68	16.92	21.67	27.88
10	4.87	9.34	15.99	18.31	23.21	29.59
11	5.58	10.34	17.28	19.68	24.73	31.26
12	6.30	11.34	18.55	21.03	26.22	32.91
13	7.04	12.34	19.81	22.36	27.69	34.53
14	7.79	13.34	21.06	23.68	29.14	36.12
15	8.55	14.34	22.31	25.00	30.58	37.70
16	9.31	15.34	23.54	26.30	32.00	39.25
17	10.09	16.34	24.77	27.59	33.41	40.79
18	10.86	17.34	25.99	28.87	34.81	42.31
19	11.65	18.34	27.20	30.14	36.19	43.82
20	12.44	19.34	28.41	31.41	37.57	45.32
21	13.24	20.34	29.62	32.67	38.93	46.80
22	14.04	21.34	30.81	33.92	40.29	48.27
23	14.85	22.34	32.01	35.17	41.64	49.73
24	15.66	23.34	33.20	36.42	42.98	51.18
25	16.47	24.34	34.38	37.65	44.31	52.62
26	17.29	25.34	33.56	38.89	45.64	54.05
27	18.11	26.34	36.74	40.11	46.96	55.48
28	18.94	27.34	37.92	41.34	48.28	56.89
29	19.77	28.34	39.09	42.56	49.59	58.30
30	20.60	29.34	40.26	43.77	50.89	59.70
40	29.05	39.34	51.81	55.76	63.69	73.40
50	37.69	49.33	63.17	67.50	76.15	86.66
60	46.46	59.33	74.40	79.08	88.38	99.61
70	55.33	69.33	85.53	90.53	100.43	112.32
80	64.28	79.33	96.58	101.88	112.33	124.84
90	73.29	89.33	107.57	113.15	124.12	137.21
100	82.36	99.33	118.50	123.34	135.81	149.45

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Studies in Biology No 43, Edward Arnold (Publishers) Ltd