Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
2013

Biology

Assessment Unit A2 2

assessing

Biochemistry, Genetics and Evolutionary Trends

[AB221]

AB221

MONDAY 3 JUNE, MORNING

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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Examiner Only	
Marks	Remark

Section A

1 The light-dependent stage of photosynthesis involves photosystems which are affected by both light intensity and wavelength.

(a) State precisely where the light-dependent stage takes place in the chloroplast.

____ [1]

(b) With reference to the events within the photosystems, explain the effect of an increased light intensity.

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____ [2]

(c) Explain the effect of different wavelengths of light on the activity of the pigment molecules within the photosystems.

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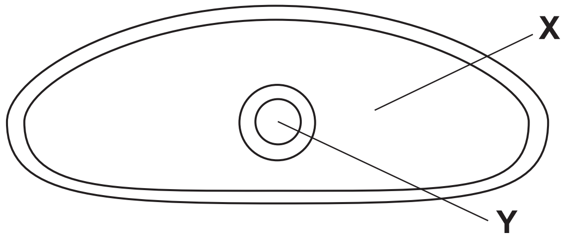
____ [2]

Examiner Only	
Marks	Remark

2 **(a)** The diagram below represents a transverse section through a planarian (phylum Platyhelminthes).



(i) State the name of the body layer labelled **X**.

_______________________________ [1]

(ii) Identify the region labelled **Y**.

_______________________________ [1]

(iii) The planarian has a flattened body shape. Explain the advantage of this body shape to the planarian.

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_______________________________ [2]

(b) Earthworms belong to the phylum Annelida. Annelids possess a coelom and are described as coelomate.

(i) Define precisely the term coelomate.

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_______________________________ [1]

(ii) Suggest **one** advantage for the possession of a coelom.

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_______________________________ [1]

Examiner Only: Marks | Remark

(c) Earthworms are detritivores and they feed by ingesting leaves and other organic material into their gut. Digestion in earthworms is extracellular.

(i) With reference to the earthworm, describe what is meant by extracellular digestion.

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____ [1]

(ii) The digestive system of annelids may be regarded as being more highly adapted (evolved) than in platyhelminthes. Describe **one** way in which they are more highly adapted and explain the advantage of this adaptation.

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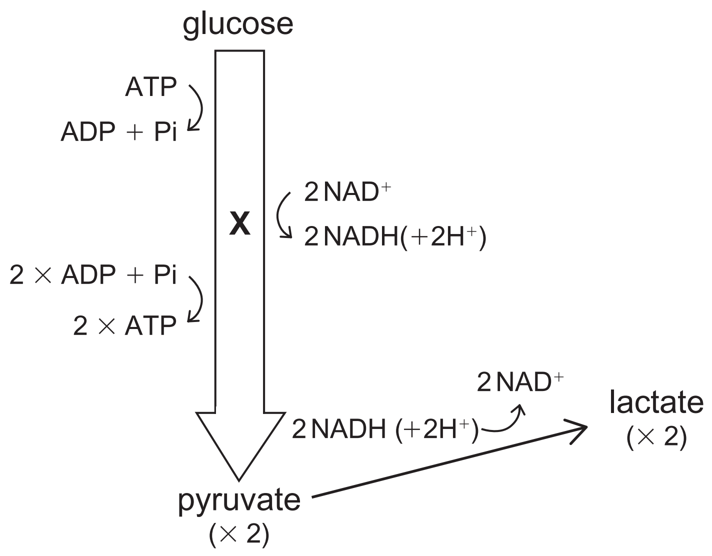
____ [2]

Examiner Only	
Marks	Remark

3 **(a)** The diagram below summarises anaerobic respiration in muscle cells.



(i) Name process **X** in which glucose is converted to pyruvate.

______________________________ [1]

(ii) The production of lactate allows process **X** to continue where oxygen is limited. Explain how.

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______________________________ [2]

(b) **(i)** Anaerobic respiration takes place where the availability of oxygen is limited. Describe **one** advantage of this in highly active muscle cells.

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______________________________ [1]

(ii) Anaerobic respiration in muscle cells leads to the build up of an oxygen debt. Describe what is meant by an 'oxygen debt'.

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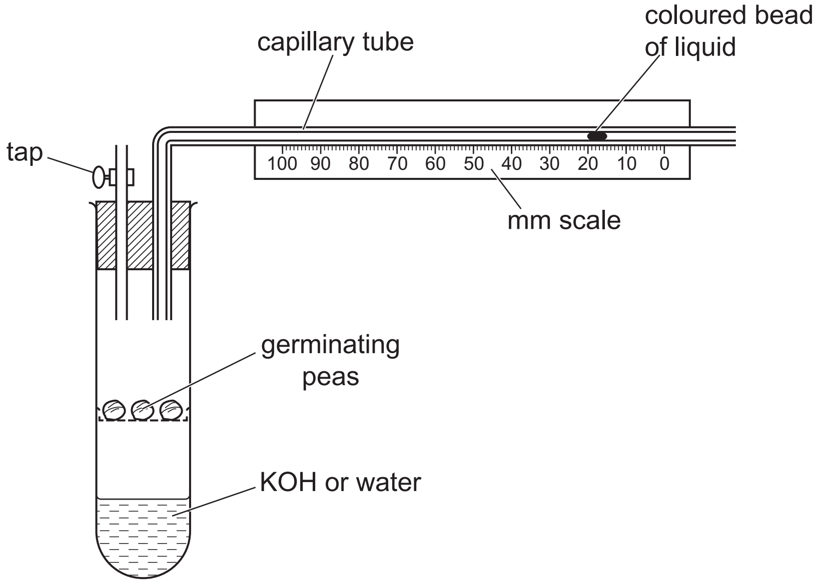
______________________________ [1]

Examiner Only	
Marks	Remark

(c) Anaerobic respiration in muscle tissue does not produce carbon dioxide as a waste product. However, anaerobic respiration in fungi and plants produces carbon dioxide.

The diagram below shows one type of simple respirometer.



Devise a plan for an investigation using the respirometer to determine if a sample of germinating peas is respiring anaerobically. Your plan should outline the experimental set-up, the control of variables, the collection of data and how you could determine if anaerobic respiration is taking place. (You do not need to give a detailed procedure for the investigation.)

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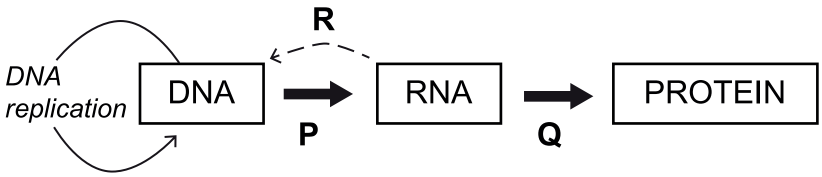
____ [4]

Examiner Only: Marks | Remark

4 **(a)** The diagram below represents the transfer of information at the molecular level – from the instructional code in DNA to the synthesis of proteins.



(i) Name processes **P** and **Q**.

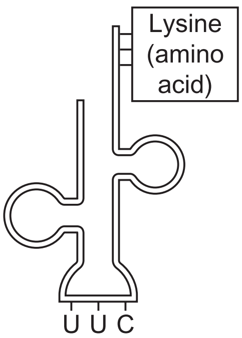
P ______________________ **Q** ______________________ [1]

(ii) Suggest why process **R** does not normally take place in cells.

____

____ [1]

(b) Transfer RNA has an important role in protein synthesis. The diagram below represents a molecule of transfer RNA (to which a particular amino acid is attached).



Using the diagram, explain the function of tRNA.

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____ [3]

(c) The range of DNA (the gene pool) in a species equates to its genetic variability. Twenty years ago there were just over 20 California condor birds (*Gymnogyps californianus*) living in the wild and the species was at grave risk of extinction. The small number of surviving members limited the genetic variability that natural selection could act on. Furthermore, a significant number of the species carried a recessive allele for a lethal form of dwarfism.

DNA (nucleotide) sequencing is allowing scientists to analyse the different alleles at many gene loci, a process that could have major conservation value.

(i) Knowledge of the DNA sequence of a genome allows specific alleles to be identified. Name the genetic 'tool' used for this identification.

____ [1]

(ii) Using the information provided, suggest how the ability to identify specific alleles, followed by selective breeding, can help conserve the species.

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____ [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

5 **(a)** In the ABO blood grouping system, a single gene with three alleles (I^A, I^B and I^O) controls the production of the antigens that determine an individual's blood group. I^A and I^B are co-dominant and each is dominant to I^O.

(i) State the possible genotypes for an individual who is:

Blood group A ___________________________________

Blood group AB ___________________________________ [2]

(ii) In a particular family, the father is blood group A and the mother is blood group B. They have four children, each with a different blood group.

Draw a genetic diagram below to show how it is possible for the parents to have four children all with different blood groups.

[3]

Examiner Only
Marks | Remark

(iii) Using the information provided, explain fully why it is possible for the mother (blood group B) to donate blood safely to only two of her children and not the other two.

[3]

(b) The rhesus factor results in another type of blood grouping. Individuals can be either rhesus positive or rhesus negative. The allele for rhesus positive (represented by **D**) is dominant.

In a population of 400 it was found that the frequency of the rhesus negative allele (represented by **d**) was 0.150.

(i) Using the Hardy-Weinberg equation, calculate the number of individuals who are heterozygous for the rhesus factor. (Show your working.)

Answer ______________________ [3]

(ii) State **one** condition that must be met for the Hardy-Weinberg equation to apply.

[1]

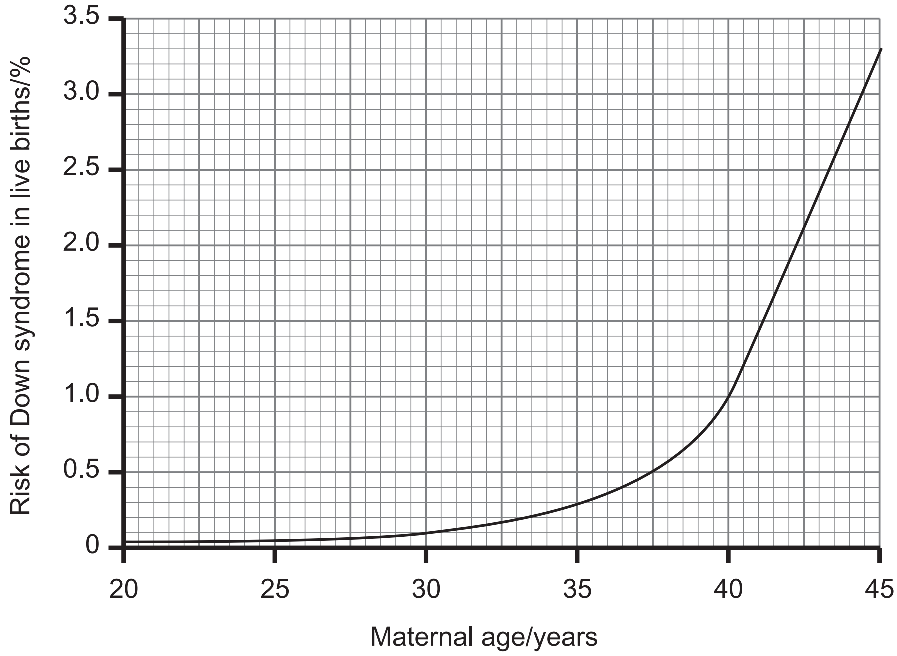
Examiner Only	
Marks	Remark

6 In humans, three copies of chromosome number 21 result in the medical condition Down syndrome. The condition arises when a chromosome mutation causes two copies of chromosome number 21 to occur in an egg. When this egg is fertilised with a normal sperm, a zygote is produced with the 47 chromosomes characteristic of Down syndrome.

(a) Name the type of chromosome mutation involved in Down syndrome.

______________________________ [1]

(b) There is a close positive correlation between the incidence of Down syndrome and the age of the mother at the time of birth. The graph below shows the relationship between the age of the mother and the risk of having a baby with Down syndrome.



(i) Determine the risk of having a Down syndrome baby at age

30 ______________________________ % live births

40 ______________________________ % live births [1]

Examiner Only
Marks | Remark

Amniocentesis is used to diagnose whether a pregnancy is likely to produce a child with Down syndrome. This is an invasive procedure which involves removal of fluid containing foetal cells from the womb. If this shows that the developing foetus has Down syndrome, the parents are offered the option to terminate the pregnancy. However, amniocentesis carries a 1% risk of miscarriage (loss of foetus). Only mothers over the age of 35 years are routinely offered amniocentesis for Down syndrome.

(ii) Using the information provided, explain fully why only pregnant mothers over 35 years of age are normally offered amniocentesis screening.

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____ [2]

(iii) Most Down syndrome children are born to mothers under the age of 35 years. Suggest why.

____

____ [1]

Examiner Only	
Marks	Remark

(c) Polyploidy is another type of chromosome mutation. Polyploidy has been very significant in plant speciation.

(i) State how polyploidy differs from the type of chromosome mutation involved in Down syndrome.

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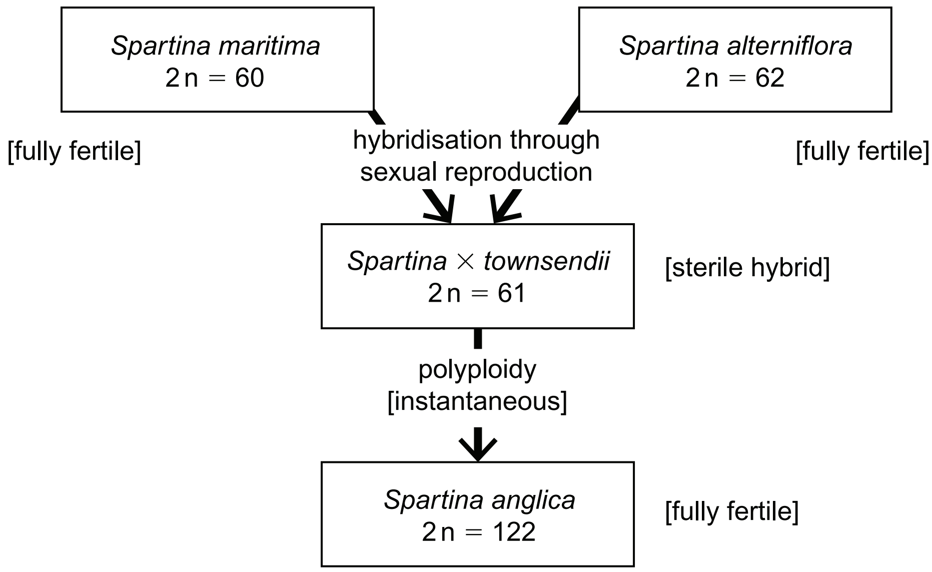
____ [1]

The following diagram outlines the process of speciation in the genus *Spartina*.



(ii) Explain how speciation by polyploidy (as shown above) differs from allopatric speciation.

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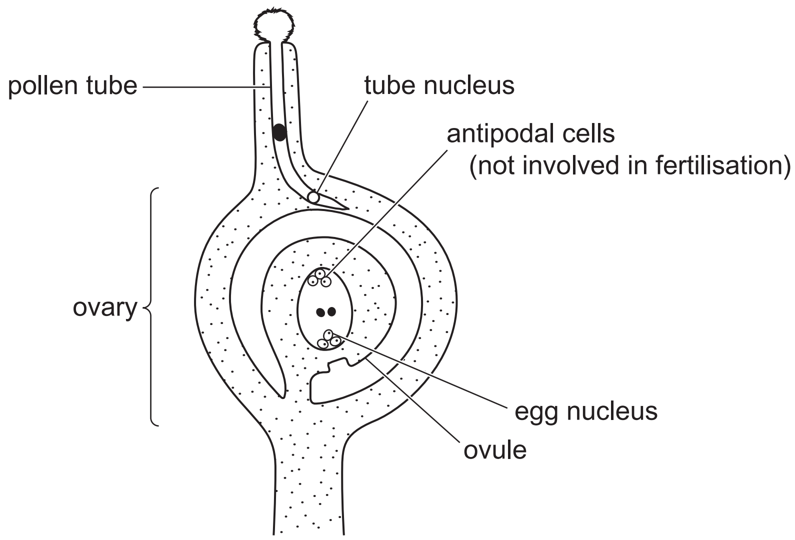
____ [3]

(iii) Give **one** commercial application of polyploidy.

____ [1]

7 **(a)** The diagram below shows a section through part of a flower. The diagram represents the stage between pollination and fertilisation in a flowering plant.



(i) Identify and label **on the diagram** above:

– the generative nucleus

– the embryosac [2]

(ii) Describe the sequence of events that take place between the stage represented in the diagram above and the completion of fertilisation.

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____ [3]

Examiner Only	
Marks	Remark

Examiner Only
Marks | Remark

(b) Following fertilisation, the ovule develops into a seed within the protective ovary. In wild garlic (*Allium ursinum*), a woodland herb, there are two ovules within each ovary. Therefore, potentially each ovary can produce two seeds, but in reality may produce two, one or none, depending on the successful completion of pollination and/or fertilisation.

In an investigation of seed size in this species, the dry masses of seeds in the following categories were measured:

– seeds produced when only one seed developed in an ovary;

– seeds produced when two seeds developed in an ovary.

The results are shown in the following table.

	Seed category	
	One seed per ovary	**Two seeds per ovary**
Number of seeds in sample (n)	50	50
Mean dry mass of seed ($\bar{x}$) /mg	7.61	6.37
Standard deviation (error) of the mean ($\hat{\sigma}_{\bar{x}}$)	0.34	0.41

(i) Suggest why the mean dry mass of a seed is bigger when there is only one seed per ovary.

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____ [1]

The *t*-test can be used to compare the two categories of seed mass.

(ii) State the null hypothesis for this test.

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____ [1]

(iii) Calculate the value of *t* using data from the table opposite.
(Show your working.)

Examiner Only	
Marks	Remark

Answer ______________________ [2]

(iv) State the probability value for the calculated *t*.

______________________ [1]

(v) State your conclusion about the seed size in the two categories.

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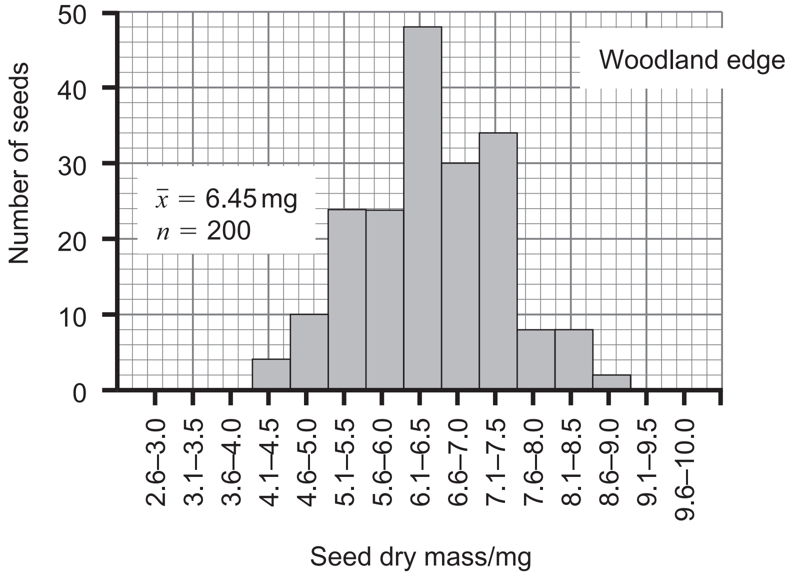
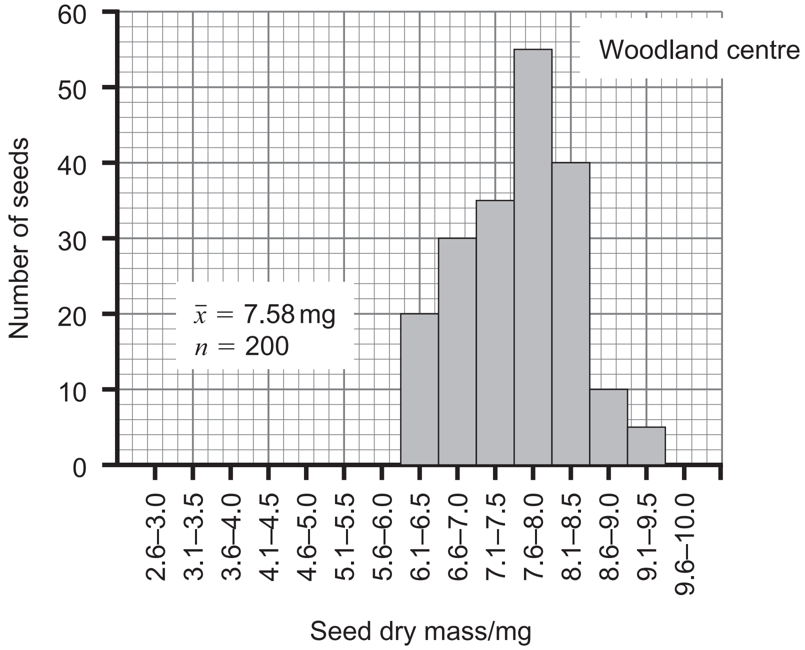
____ [2]

Examiner Only
Marks | Remark

(c) In an investigation analysing seed masses in different environments, samples of seeds from wild garlic were collected at both the woodland edge and from deep within the wood (woodland centre). The results are shown in the graphs below.





(i) Using the information provided, explain **one** way in which the data may be considered reliable.

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____ [1]

Examiner Only: Marks | Remark

Wild garlic, the same species as analysed in part **(b)**, is insect pollinated and, typically, a wide range of insect species are involved in its pollination. However, many of the insect species involved are grassland species that rarely penetrate deeply into woodland.

(ii) Describe the differences between the seed masses at the 'woodland edge' and the 'woodland centre'.

[2]

(iii) Using the information provided, suggest explanations for these differences.

[3]

Section B

Examiner Only	
Marks	Remark

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

8 Gene technology is opening up many medical and commercial opportunities through the production of transgenic organisms and in gene therapy.

(a) Describe the processes of obtaining desired genes and their subsequent transfer into the cells of organisms. [8]

(b) Discuss the benefits and potential problems arising from the production of transgenic organisms and from gene therapy. [8]

Quality of written communication [2]

(a) Describe the processes of obtaining desired genes and their subsequent transfer into the cells of organisms.

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(b) Discuss the benefits and potential problems arising from the production of transgenic organisms and from gene therapy.

Examiner Only	
Marks	Remark

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Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER

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General Certificate of Education

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:

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

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

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

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