Rewarding Learning

ADVANCED
General Certificate of Education
2018

Centre Number

Candidate Number

Biology

Assessment Unit A2 2
assessing
Biochemistry, Genetics and Evolutionary Trends

AB221

[AB221]

MONDAY 11 JUNE, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
Answer **all eight** questions.

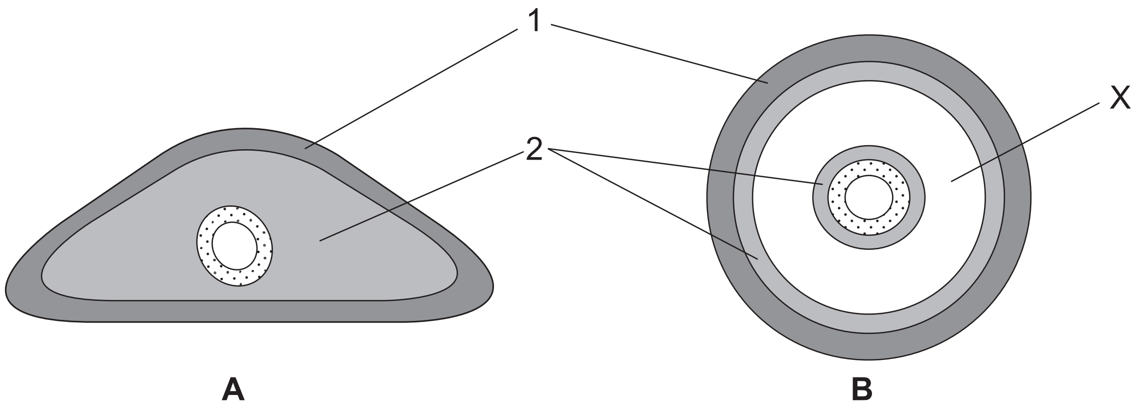
INFORMATION FOR CANDIDATES

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.

11458

Section A

1 The diagrams **A** and **B** below represent transverse sections through two different animal phyla.



(a) Identify the body layers labelled **1** and **2**.

1. ______________________________

2. ______________________________ [2]

(b) (i) Identify phylum **A**.

______________________________ [1]

(ii) Name the phylum/phyla that **B** represents.

______________________________ [1]

(c) Identify the region labelled **X** and give **one** advantage of the presence of this region in animals.

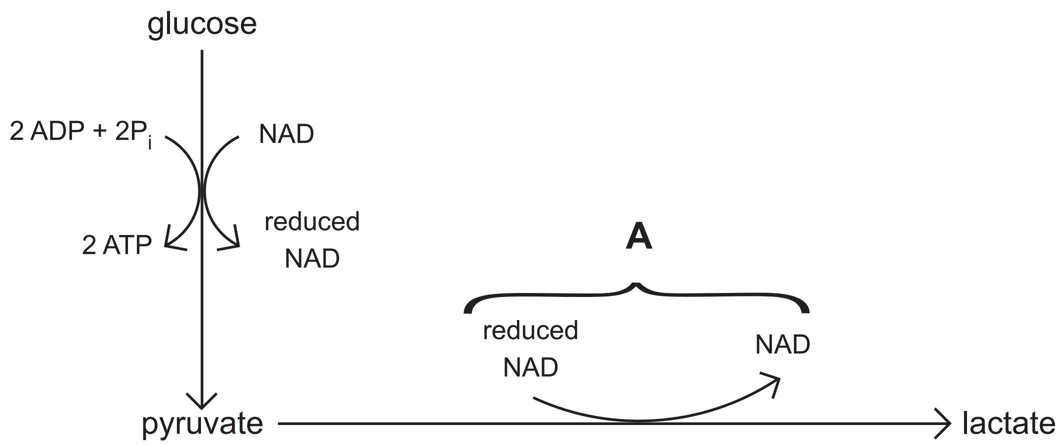
X ______________________________

Advantage ______________________________

______________________________ [2]

2 Anaerobic respiration is not limited by the availability of oxygen.

(a) The main stages of anaerobic respiration in mammals are summarised in the diagram below.



(i) Name the part of the cell where anaerobic respiration takes place.

______________________________ [1]

(ii) Energy release in anaerobic respiration is a very rapid process. Using the diagram above and your knowledge, suggest an explanation for this.

____

____

____ [1]

(iii) Explain the importance of **A**.

____

____

____ [1]

(b) 'Facultative anaerobes' are organisms that are able to respire glucose anaerobically, but will respire aerobically when oxygen is available.

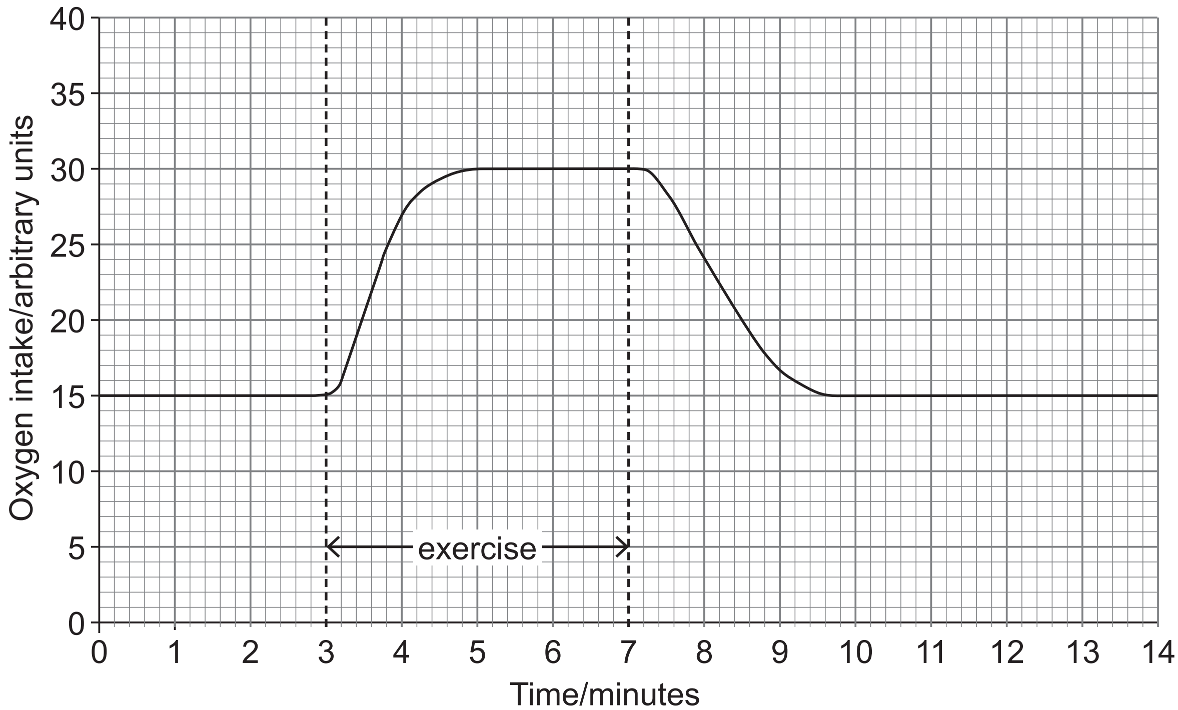
(i) Suggest why many organisms favour aerobic over anaerobic respiration.

[2]

(ii) Explain fully the advantage of anaerobic respiration to a mammal.

[2]

(c) The graph below shows how the intake of oxygen in an individual changes during and after exercise.



(i) On the graph, shade the area which represents the oxygen debt. [1]

(ii) State the function of the oxygen debt.

____

____

____ [1]

(d) Describe **two** differences between the process of anaerobic respiration in plants and animals.

1. ____

____

2. ____

____ [2]

[Turn over

3 Bacteria are prokaryotes and their chromosomal DNA is found as a single large loop within the cell. A number of smaller rings of DNA called plasmids are also present. Genes for antibiotic resistance are often present in plasmids.

The genomes of some bacteria can be more prone to change than the genomes of eukaryotes. For example, plasmids can be exchanged between bacterial cells when they are in close contact, even if the bacteria are different species. In addition, the DNA repair process in plasmids is less effective than in chromosomal DNA, contributing to a high mutation rate.

Antibiotic resistance genes work in a variety of ways. For example, some code for membrane carriers which are able to remove antibiotics from inside bacterial cells. Globally, the number of antibiotic-resistant populations of bacteria is increasing.

A bacterial population can grow very rapidly; in optimum conditions bacteria can reproduce every 20 minutes by division, during which a fully grown cell splits into two daughter cells.

(a) Apart from organisation of DNA, state **one** difference between prokaryotic and eukaryotic cells.

____ [1]

(b) **(i)** As with plant and animal populations, bacterial populations show genetic variation which can arise from various sources. Using the information provided, describe **one** feature of bacteria which increases genetic variation and **one** feature which decreases genetic variation in populations.

Feature which **increases** genetic variation

____

____

Feature which **decreases** genetic variation

____

____ [2]

(ii) Explain fully why the number of antibiotic-resistant populations of bacteria is increasing.

____

____

____

____

____

____

____

____

____ [3]

Organisms may be classified according to characteristics including morphology, cell structure and genetic makeup.

(iii) Suggest **two** reasons why scientists can find it difficult to classify many types of bacteria.

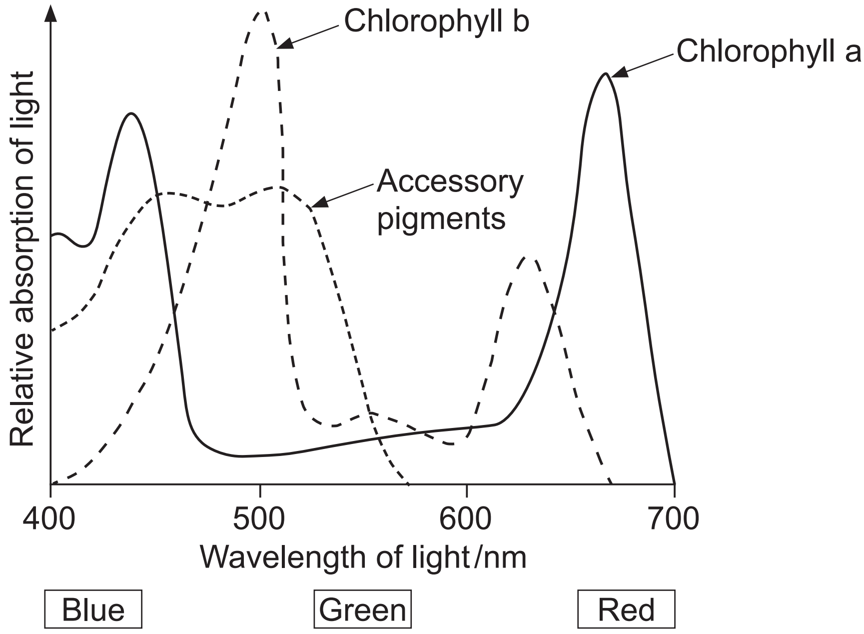
1. ____

____

2. ____

____ [2]

4 **(a)** The graph below shows the absorption spectrum for the photosynthetic pigments in a typical plant.



(i) Using the information provided, explain why plant leaves are normally green in colour.

____

____

____

____

____ [2]

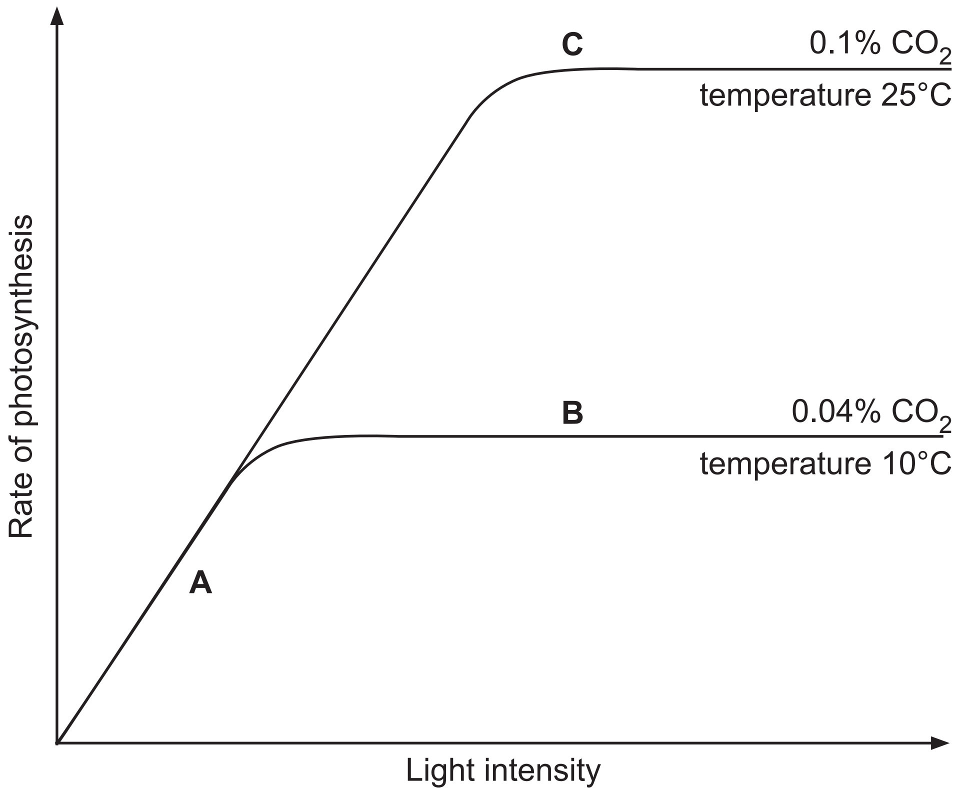
(ii) An action spectrum may also be plotted.
Describe what is meant by the term 'action spectrum'.

____

____

____ [1]

(b) The graph below summarises the relationship between light intensity and rate of photosynthesis in different conditions of temperature and CO_2 availability.



(i) Outline how scientists investigating this relationship would have accurately measured the **rate** of photosynthesis.

____

____

____

____

____

____ [2]

[Turn over

(ii) Using your knowledge of the light-dependent reaction, explain why the rate of photosynthesis is higher at **B** than at **A**.

[2]

(iii) Using your knowledge of the light-independent reaction, explain why the rate of photosynthesis is higher at **C** than at **B**.

[4]

(c) Many British plant species grow fastest at a temperature of approximately 25°C. Temperatures greater than this can cause a very high rate of transpiration. The plants' response to this can result in a reduction of growth rate.

With reference to the response of plants to high transpiration rates, explain why growth is faster at 25°C than at 30°C.

____

____

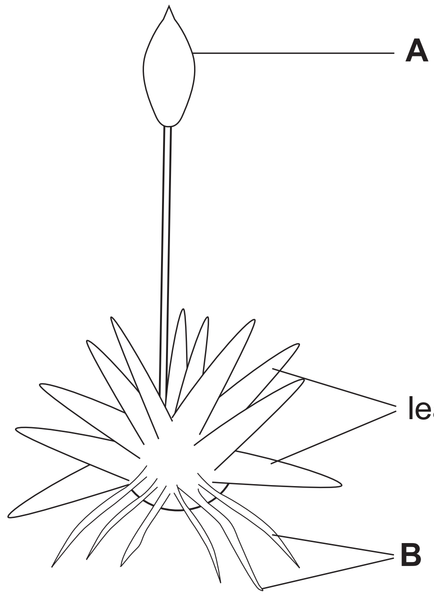
____

____

____

____ [2]

5 (a) In terms of evolutionary development, mosses (bryophytes) are the least evolved group in the plant kingdom. The typical moss structure is represented in the diagram below.



(i) Identify the structures labelled **B**.

______________________________ [1]

(ii) State **two** ways in which the leaf-like structures differ from true leaves.

1. ______________________________

2. ______________________________ [2]

(iii) Describe fully the part of the moss life cycle which occurs inside the structure labelled **A**.

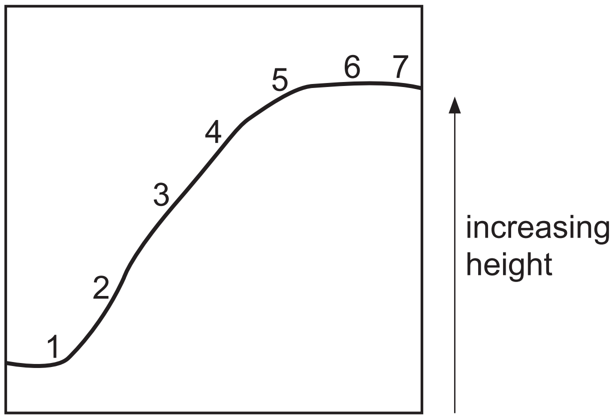
____

____

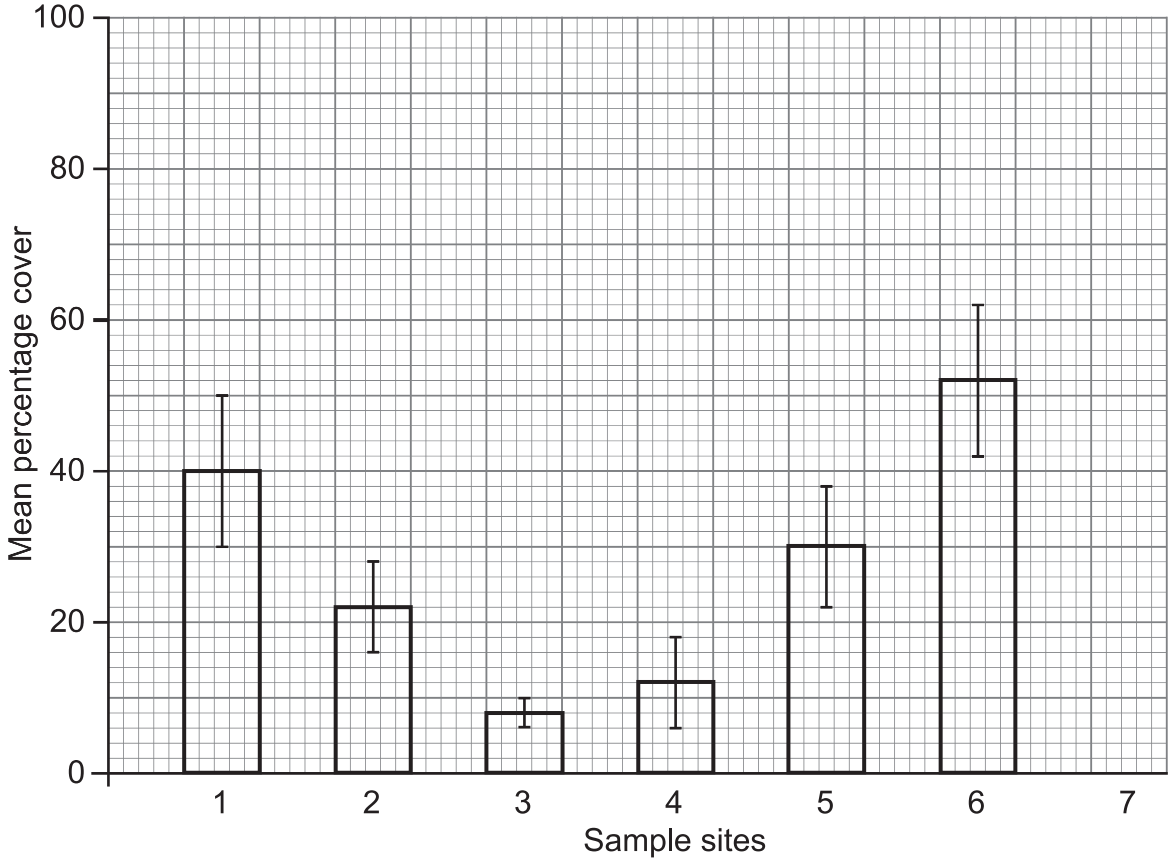
____

____ [2]

(b) Mosses of the genus *Sphagnum* are typically found in wet habitats with high levels of rainfall and poor drainage. The mean percentage cover of *Sphagnum* was investigated at a number of sites on a mountain. The position of the sample sites is shown in the diagram below.



The mean percentage cover of *Sphagnum* for sample sites 1–6 is shown in the graph below. Associated 95% confidence limits are included.



(i) The mean percentage cover of *Sphagnum* in site 7 was 58% and the standard deviation of the mean (standard error) ($\hat{\sigma}_{\bar{x}}$) was 2.422 (n=25).

Using the information given and the Statistics Sheets provided, calculate 95% confidence limits for site 7.

(Show your working.)

upper limit ____________________

lower limit ____________________ [3]

(ii) Complete the graph by plotting mean percentage cover and 95% confidence limits for site 7. [1]

(iii) Describe the trend shown by the results and suggest an explanation for the distribution of *Sphagnum* on this mountain.

____

____

____

____

____

____ [2]

Ferns (pteridophytes) are more highly adapted than mosses for terrestrial life. Fern sporophytes are common in hedgerows and woodland and are easily recognised by their finely-divided leaves and the presence of spore-producing sporangia on the lower surface of leaves. The sporophytes of fern species can grow to heights of one metre or more.

(c) Using the information provided, explain fully **one** advantage of ferns reaching heights of one metre or more.

____

____

____

____

____________________ [2]

BLANK PAGE

DO NOT WRITE ON THIS PAGE

(Questions continue overleaf)

6 **(a)** Mendel's second law of inheritance is known as 'the law of independent assortment'. Explain the meaning of this law with respect to dihybrid inheritance.

____

____

____ [1]

(b) Coat colour in Doberman dogs is determined by the interaction between two genes. One gene determines the overall colour and has the alleles **B/b**. The second gene dilutes the colour and has the alleles **D/d**.

Black coat colour occurs when the dog possesses at least one **B** allele. Dark red coats are found in dogs which lack the dominant **B** allele.

These colours can be diluted by the presence of two recessive **d** alleles to produce a faded colour. The effect of this in the presence of a **B** allele is blue coat (faded black) while the double homozygous recessive genotype results in a fawn coat (faded red).

(i) State all the genotypes that produce:

- dark red coat colour ____

- blue coat colour ____ [2]

(ii) Complete a genetic diagram to show the ratio of genotypes and phenotypes produced from the following cross:

BbDd × Bbdd

[5]

[Turn over

(c) The Xolo is a breed of dog native to Mexico. A dominant allele **H** gives rise to a hairless variety of the dog, while the recessive allele for the gene, **h**, produces a normal hairy coat.

Breeding two hairless dogs together produces both hairless and hairy offspring, in the ratio of 2 hairless : 1 hairy. This ratio can be best explained by a combination of alleles that is lethal.

Draw a genetic diagram to explain this ratio.

[3]

(d) In terms of dog populations in general, suggest **one** reason why it would not be appropriate to use the Hardy-Weinberg equation to calculate allele and genotype frequencies.

____

____

____ [1]

7 (a) Gene technology has many applications, one of which is the manufacture of substances of medical importance such as insulin. Before the application of genetic engineering, the insulin required for the treatment of diabetes had to be extracted from pigs and cows in abattoirs.

(i) Name the group of organisms that is used to produce insulin in genetic engineering.

_______________________________ [1]

(ii) Suggest **one medical** advantage of making insulin for the treatment of diabetes by genetic engineering, rather than obtaining insulin from dead livestock.

____

____

_______________________________ [1]

(b) Gene therapy is another application of gene technology. Cystic fibrosis is caused by the presence of two recessive alleles for a particular gene. Impaired lung function is one symptom of this condition and part of a treatment programme can involve the use of liposomes or viruses to insert functioning genes into the cells of the lung.

However, the use of gene therapy to treat cystic fibrosis has not been very successful for a number of reasons. One of these is the difficulty of getting functional genes into a high enough proportion of lung cells.

Suggest **one** reason why only a small number of lung cells gain the functional gene in gene therapy.

____

____

_______________________________ [1]

(c) Gene technology has recently been trialled in a new treatment for the genetic disease sickle cell anaemia. This disease is caused by a mutation in one of the genes which codes for haemoglobin. As a result, red blood cells have a distorted shape and may block narrow capillaries.

Bone marrow transplants can be used to treat sickle cell anaemia, since red blood cells are produced from stem cells in bone marrow. However, these transplants are often unsuccessful.

(i) Using your knowledge of the immune system, suggest why a bone marrow transplant may be unsuccessful.

____

____

____ [1]

It is hoped that the new treatment involving gene technology will prove more successful in treating sickle cell anaemia.

Scientists have been able to 'edit' the genes in the stem cells in the bone marrow of the patient. This involved removing the mutated sequence and replacing it with a functional version.

(ii) With reference to the limitations of traditional gene therapy, explain fully the advantages of this technique.

____

____

____

____

____

____

____

____

____

____

____ [4]

(iii) Suggest **one** possible disadvantage of this technique.

____

____ [1]

Section B

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

8 Protein synthesis is the process by which polypeptide and protein molecules are made in the cell. This is based on the genetic code carried by DNA in the nucleus.

(a) Describe and explain the roles of DNA, RNA and ribosomes in protein synthesis. [12]

(b) Base substitutions are DNA mutations that may affect the protein produced. Explain how the protein produced could be affected by a base substitution and how some base substitutions do not affect the protein produced. [4]

Quality of written communication [2]

(a) Describe and explain the roles of DNA, RNA and ribosomes in protein synthesis.

(b) Base substitutions are DNA mutations that may affect the protein produced. Explain how the protein produced could be affected by a base substitution and how some base substitutions do not affect the protein produced.

THIS IS THE END OF THE QUESTION PAPER

BLANK PAGE

DO NOT WRITE ON THIS PAGE

BLANK PAGE

DO NOT WRITE ON THIS PAGE

BLANK PAGE

DO NOT WRITE ON THIS PAGE

DO NOT WRITE ON THIS PAGE

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

Examiner Number

Rewarding Learning

ADVANCED
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:

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

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

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

COUNCIL FOR THE CURRICULUM EXAMINATIONS AND ASSESSMENT 29 Clarendon Road, Clarendon Dock, Belfast BT1 3BG
+44 (0)28 9026 1200 +44 (0)28 9026 1234 +44 (0)28 9024 2063 info@ccea.org.uk www.ccea.org.uk