Oxford Cambridge and RSA

Wednesday 19 June 2024 – Morning

A Level Biology B (Advancing Biology)

H422/03 Practical skills in biology

Time allowed: 1 hour 30 minutes

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **16** pages.

ADVICE
- Read each question carefully before you start your answer.

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1

(a) ATP, DNA and tRNA are molecules that have some similarities but several differences in structure.

The table lists structural features of ATP, DNA and tRNA.

Use ticks (✓) to indicate the structural features that are present in ATP, DNA and tRNA.

Structural feature	**ATP**	**DNA**	**tRNA**
Contains adenine			
Contains ribose			
Has hydrogen bonds within its molecular structure			

[3]

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(b)* Different methods are used to study DNA.

Outline the methods you would use to:

- purify DNA from plant tissue by precipitation
- separate the DNA into fragments using gel electrophoresis
- visualise the DNA bands once they have been separated.

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Extra answer space if required.

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2 A rare disease is defined as a disease that affects less than 0.05% of a population.

(a) NGLY1 deficiency is a rare disease caused by mutation in the *NGLY1* gene.

People with NGLY1 deficiency produce faulty N-glycanase 1, which is an enzyme that removes abnormal proteins.

Symptoms of NGLY1 deficiency include weak muscle tone and delayed development of speech and motor skills.

Several different mutations in the *NGLY1* gene are known to cause NGLY1 deficiency. Two of these mutations are:
- a substitution mutation of cytosine (C) to thymine (T) that causes relatively mild symptoms
- a deletion mutation of C that causes severe symptoms.

Suggest why the deletion mutation of C causes more severe symptoms than the substitution mutation.

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(b) A student researches NGLY1 deficiency and obtains secondary data for the prevalence of the disease.

The student discovers that:
- NGLY1 deficiency is a recessive genetic disease
- 75 people in the world had been diagnosed with NGLY1 deficiency in 2022
- the world population in 2022 was 7 880 000 000.

(i) Using the secondary data obtained by the student and the Hardy–Weinberg principle, estimate the number of people in the world that were heterozygous carriers of a mutant *NGLY1* allele in 2022.

Use the equations:

$p^2 + 2pq + q^2 = 1$
$p + q = 1$

Give your answer to **4** significant figures.

Number of heterozygous carriers in the world = ... **[3]**

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(ii) Suggest **two** reasons why the use of the Hardy–Weinberg principle might **not** give an accurate estimate of the number of people in the world who are carriers of a mutant *NGLY1* allele.

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(c) The effect of NGLY1 deficiency on muscle tissue has been studied by dissecting muscle tissue and observing it under a microscope.

Describe **two** safety precautions that should be taken when dissecting muscle tissue.

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[2]

(d) Suggest why few clinical trials are carried out to test treatments for rare diseases.

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(e) In 2022, the government of the UK announced a rare diseases action plan, which outlined ways to improve the diagnosis and treatment of rare diseases.

The use of information technology is viewed as an important tool in the future diagnosis and treatment of rare diseases.

Explain how information technology **and** research into the human genome could be used in the diagnosis and treatment of rare genetic diseases.

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3 Hypothyroidism is a condition in which a person produces lower concentrations of the hormone thyroxine than normal. Thyroxine affects metabolic rate and has a role in the control of body temperature. Hypothyroidism causes a variety of symptoms.

(a)* During an investigation, a group of students plan to compare the core body temperature of people with hypothyroidism with people who do not have hypothyroidism.

Describe an experimental plan that would allow the students to collect enough data to be able to complete this investigation.

Your answer should include a method to measure core body temperature and a description of an appropriate statistical test with which to analyse the data.

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Extra answer space if required.

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(b) Hypothyroidism can affect blood pressure.

(i) Describe how to use a sphygmomanometer to measure the blood pressure of a person.

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(ii) A person with hypothyroidism compares their blood pressure measurements with a friend who does not have hypothyroidism.

- The person with hypothyroidism has measurements of $\frac{134}{82}$ mmHg.
- The person without hypothyroidism has measurements of $\frac{119}{80}$ mmHg.

Explain what conclusions can be made from these measurements about the effect of hypothyroidism on blood pressure **and** describe the limitations of this comparison.

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(c) Hypothyroidism can affect the concentration of red blood cells in a person's blood.

State a method that could be used to measure the concentration of red blood cells in a person with hypothyroidism.

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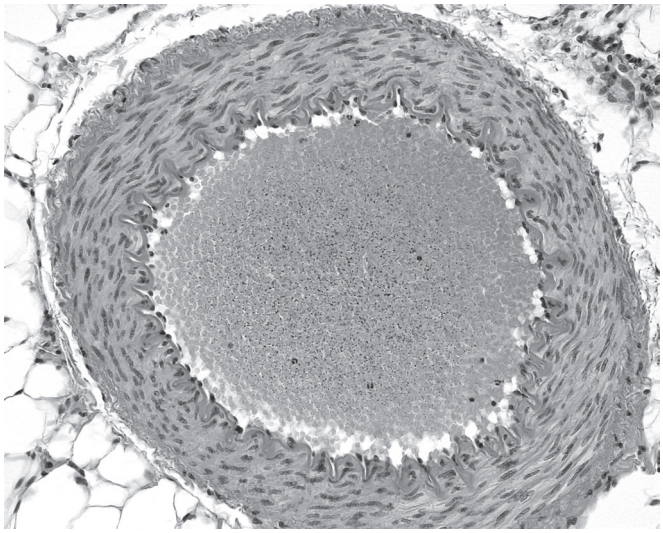
(d) One effect of thyroxine on the cardiovascular system is to cause the dilation of arteries.

This is a photomicrograph of an artery.



Draw a plan diagram of the artery in the space below.

On your diagram, label the lumen and the muscle layer of the artery.

[3]

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4 Aphids are insects that feed on fluid from phloem sieve tubes of plants.

(a) Scientists studied the genetic diversity of six populations of melon aphid, *Aphis gossypii*.

The scientists used two measures of genetic diversity:

1. percentage of polymorphic loci
2. heterozygosity, which is the proportion of individuals that have two different alleles for a particular gene, averaged over many loci.

The scientists analysed the same 6280 gene loci for each aphid.

The results are shown in the table.

Population	Number of aphids sampled	Percentage of polymorphic loci	Heterozygosity
A	10	25.96	0.180
B	10	69.43	0.153
C	10	78.54	0.172
D	9		0.178
E	7	60.78	0.214
F	10	28.57	0.180

(i) The scientists observed more than one allele at 4936 gene loci for the nine aphids from population **D**.

Calculate the percentage of polymorphic loci in population **D**.

Percentage = ... **[2]**

(ii) Evaluate whether the method used by the scientists allows an accurate comparison of genetic diversity in the six populations.

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(b) Aphids are used in experiments to measure the rate of translocation in phloem tissue.

Suggest appropriate units for the rate of translocation in phloem tissue.

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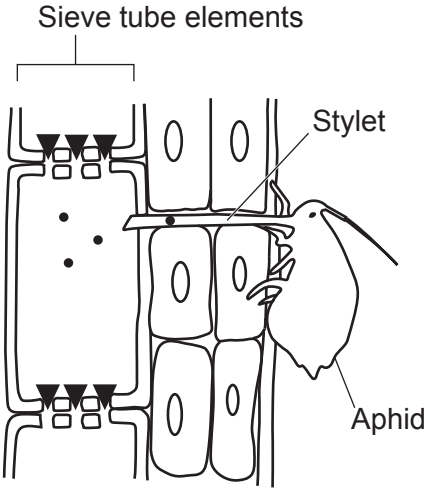
(c) An aphid feeds on a plant by inserting their stylet (a tube-like mouthpart) into a phloem sieve tube.

Pathogens can also pass through the stylet from the aphid to the phloem sieve tube.

Plants have evolved many different adaptations as defences against these pathogenic infections.

One defence adaptation is the production of callose, a type of polysaccharide, when infection is detected.

The diagram shows the deposition of callose in a plant in response to pathogenic infection after aphid feeding.



Key:

▼ Callose

• Pathogen

(i) Discuss whether the production and deposition of callose would have a significant impact on the mass of starch this plant is able to store in its sinks.

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(ii) A scientist plans to compare the concentration of callose in the phloem tissue of two groups of plants of the same species:

- plants that have not had aphids feeding on them
- plants that have had aphids feeding on them in order to infect them with pathogens.

Describe **two** potential problems that the scientist will need to consider in order to take valid measurements in this investigation.

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[2]

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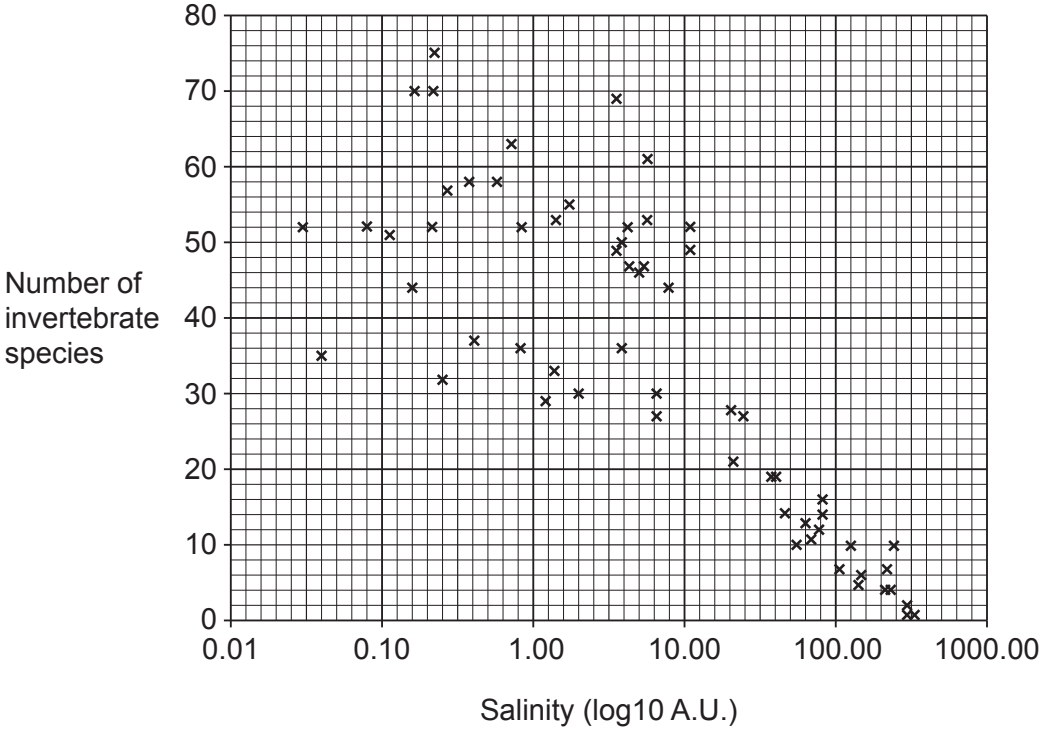
5 Human activities such as agriculture and urbanisation have resulted in an increase in salinity (the concentration of salts) in rivers and lakes.

(a) Western Australia contains many saltwater wetlands. In some cases, human activity has changed the salinity of these saltwater wetlands.

Scientists studied how the salinity of saltwater wetlands affects the number of invertebrate species present. They measured salinity and the number of invertebrate species in each wetland.

The graph shows the results of the study.



(i) Describe the results shown in the graph.

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(ii) One of the scientists plans to investigate how the number of plant species changes across one of the saltwater wetlands.

Outline how the scientist could measure the number of plant species across the saltwater wetland.

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(b) Another scientist sampled the species of fish present in a brackish lake, which has salinity that is higher than freshwater but lower than seawater.

The table shows the results of the sampling in the brackish lake.

Species	***n***	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
A	3	0.071	0.005
B	5	0.119	0.014
C	3	0.071	0.005
D	10	0.238	0.057
E	19	0.452	0.204
F	2		
		Σ =	

(i) Calculate Simpson's Index of Diversity.

Use the formula: $D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$

n = number of individuals of each species present in the sample
N = total number of all individuals of all species

Simpson's Index of Diversity (D) = ... **[3]**

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(ii) A different group of scientists had sampled the fish species in the same lake 20 years earlier.

This group of scientists calculated a *D* value of 0.709.

Using your answer from **(i)**, state what conclusion can be made about how the biodiversity of fish species has changed over the 20-year period.

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(iii) Suggest why the comparison between the two values of *D* might not be valid.

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END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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