Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

13 May 2025

Zone A morning | **Zone B** morning | **Zone C** morning

Candidate session number

2 hours 30 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.

2225 – 6021

23 pages

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Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. Angora rabbits (*Oryctolagus cuniculus*) have soft and silky coats with fine hairs that grow about 30 mm per month. These hairs can be collected and used as wool. Hair growth in mammals depends on stem cells in the base of hair follicles called dermal papilla cells.

Research was carried out to investigate the role of the *WIF1* gene in hair growth. Wool was collected from 6-month-old angora rabbits. Expression of the *WIF1* gene was assessed by measuring the quantity of *WIF1* mRNA produced in cells taken from each rabbit. The rabbits were divided into groups according to their rate of wool production (low or high).

The table shows mean wool production per rabbit in the low and high wool production groups and relative expression of the *WIF1* gene.

	Wool production group	
	Low	**High**
Mean wool production per rabbit / g	245.00	480.00
Relative expression of *WIF1* gene	1.00	0.23

(This question continues on the following page)

(Question 1 continued)

(a) Calculate the difference in mean wool production between the high and low wool production groups. [1]

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(b) (i) Identify the relationship between wool production and relative expression of *WIF1*. [1]

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(ii) Discuss whether the data in the table shows a causal relationship between *WIF1* expression and wool production. [2]

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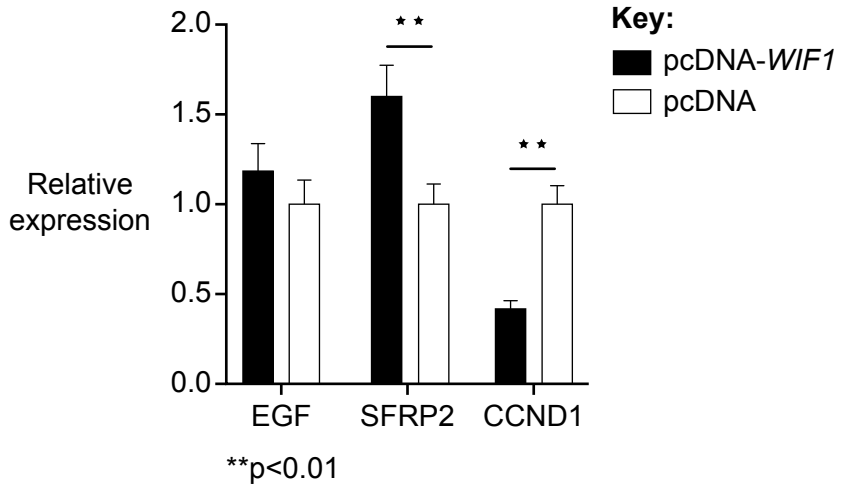
(Question 1 continued)

Proteins produced by expressing the *WIF1* gene bind to a group of glycoproteins used in chemical signalling. This signalling can promote or inhibit transcription of other genes.

Rabbit dermal papilla cells growing in liquid tissue culture were modified in two different ways by introducing a genetically engineered loop of DNA (plasmid) with or without a copy of the *WIF1* gene:

- pcDNA-*WIF1*: a plasmid carrying a copy of the *WIF1* gene
- pcDNA: the same plasmid without the *WIF1* gene

The expression of three genes, EGF, SFRP2 and CCND1, was measured in the modified rabbit dermal papilla cells. The bar chart shows the results.



(c) Identify the control treatment. [1]

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(d) Outline the effect of pcDNA-*WIF1* on the expression of each of the three genes. [3]

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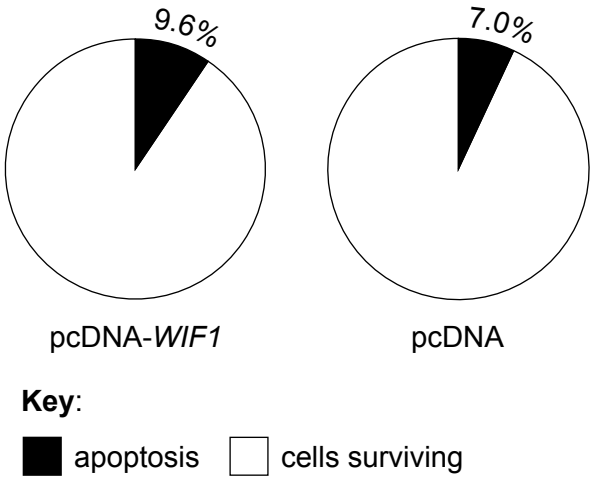
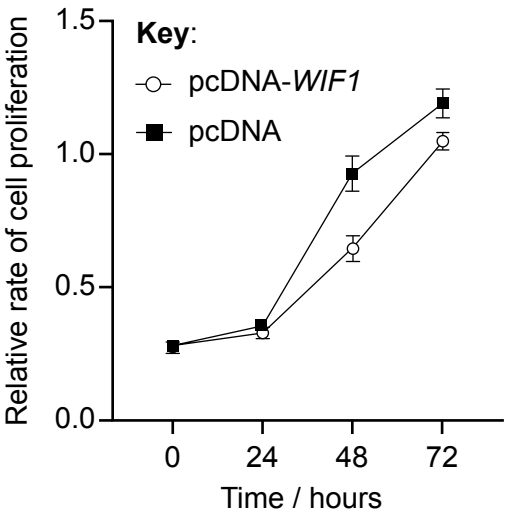
(Question 1 continued)

In other species, expression of *WIF1* has been found to affect rates of apoptosis (programmed cell death) and cell proliferation. These two processes were measured in the modified rabbit dermal papilla cells. The pie charts show apoptosis rates, and the graph shows cell proliferation rates.





(e) Explain how expression of the *WIF1* gene could affect the rate of wool production in angora rabbits, using evidence from the data in the question. [4]

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Please **do not** write on this page.

Answers written on this page
will not be marked.

2. Average human internal (core) body temperature is 36.4 °C, with slight variations between day and night. The average surface temperature of the Earth in the 20th century was 13.9 °C. It has now risen to 14.8 °C.

(a) (i) Outline **one** change that happens in the human body in response to a rise in body temperature above 36.4 °C. [1]

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(ii) Identify with a reason whether this response is positive or negative feedback. [1]

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(b) Explain how the burning of fossil fuels has contributed to the increase in the Earth's temperature. [2]

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(c) Melting polar ice due to global warming is reducing reflection of sunlight from the Earth. Identify with a reason whether this will result in positive or negative feedback. [1]

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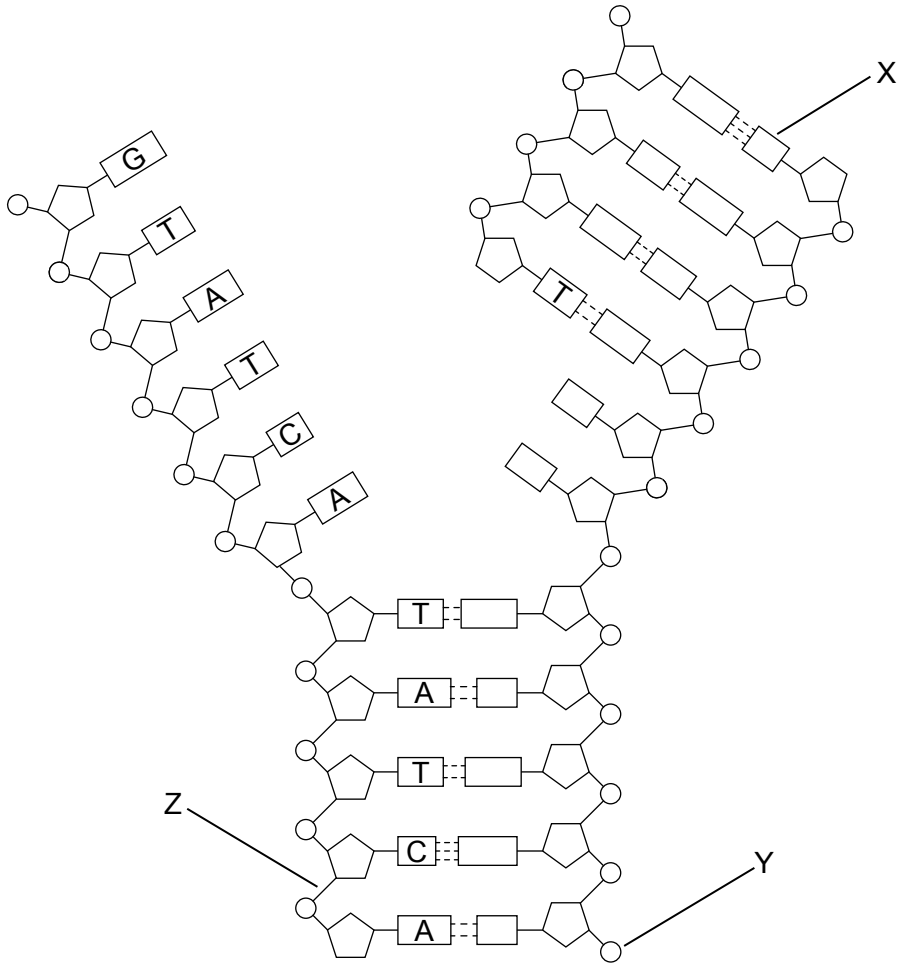
3. The diagram shows a nucleic acid, with some of the bases indicated.



(a) Identify the type of nucleic acid shown in the diagram. [1]

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(b) Determine with a reason whether the diagram shows transcription or replication. [1]

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(Question 3 continued)

(c) Deduce the base indicated by X on the diagram. [1]

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(d) Identify the terminal indicated by Y on the diagram. [1]

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(e) (i) Identify the type of bond indicated by Z on the diagram. [1]

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(ii) Several enzymes can catalyse the formation of this type of bond. Explain how **two** enzymes catalyse it during the process shown in the diagram. [2]

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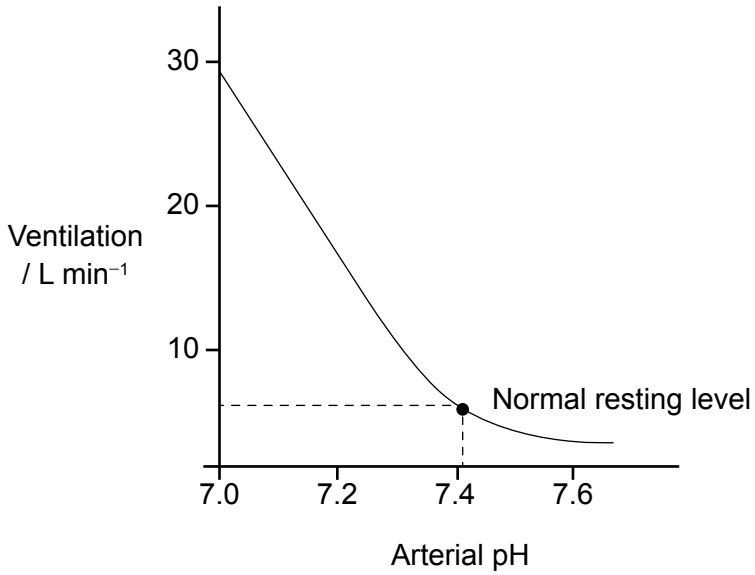
4. The graph shows the relationship between blood pH in the arteries and volume of air inhaled and exhaled per minute.



(a) State the effect of decreases in arterial pH on ventilation. [1]

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(b) Outline how the pH of arterial blood is monitored by the human body. [1]

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(Question 4 continued)

(c) Explain the main cause of pH changes in the blood. [2]

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(d) State which muscles would contract more vigorously, or more frequently, to increase the volume of air inhaled per minute. [2]

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5. The photograph shows Japanese knotweed, *Reynoutria japonica*, which is native to Japan, China and Korea. It has been introduced into other regions of the world and is now an invasive alien species in parts of Europe and North America. Dense groups of stems often develop with a height of up to 3 metres, which prevent other plants from growing.

(a) State the biological term for a group of organisms of the same species living in an area. [1]

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(b) Suggest **two** ways in which a plant such as *Reynoutria japonica* could prevent the growth of other plants. [2]

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(Question 5 continued)

(c) Some insect species form interspecific relationships with *Reynoutria japonica*. Identify the relationship with these insect species:

(i) *Apis mellifera* (honey bee), which collects nectar from the flowers of *Reynoutria japonica*; [1]

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(ii) *Aphalara itadori*, which feeds on the shoots and young leaves of *Reynoutria japonica*. [1]

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6. The micrograph shows part of a lilac (*Syringa vulgaris*) leaf in vertical section.

(a) The leaf has layers of cells with different functions. Suggest the functions of the cells in the upper epidermis and the palisade mesophyll. [2]

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(b) Explain the roles of **two** leaf structures that help with the process of gas exchange in the leaf. [2]

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(c) State the functions of xylem and phloem tissue in the leaf. [2]

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7. (a) Outline what is meant by the “root” and “node” with reference to a cladogram. [2]

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(b) Discuss the use of amino acid sequences of proteins as the basis for constructing cladograms. [3]

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(c) Identify a type of information, other than amino acid sequence, that could be used to construct a cladogram. [1]

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(d) Outline the use of parsimony analysis when choosing between different possible cladograms. [1]

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Section B

Answer **two** questions. Up to one additional mark is available for the construction of your answers for each question. Answers must be written within the answer boxes provided.

8. Members of a species typically all have the same number of chromosomes.

(a) Explain the need for both fusion of gametes and meiosis in a **sexual** life cycle. [4]

(b) Describe the events in interphase and mitosis that ensure that the chromosome number does not change during an **asexual** life cycle. [7]

(c) Discuss the barriers to hybridization between species and how polyploidy can overcome these barriers. [4]

9. The structure of membranes allows them to carry out many functions in cells.

(a) Discuss the use of membranes for compartmentalization in eukaryotic cells. [4]

(b) Describe the methods that are used to move substances into and out of cells. [7]

(c) Explain the role of membranes in the depolarization and repolarization of axons. [4]

10. All cells require a supply of energy and can transform the energy that they obtain in different ways.

(a) Explain the properties of ATP that make it useful for distributing energy within cells. [3]

(b) Describe how cells in plants use light energy to produce ATP. [7]

(c) Compare and contrast how different types of heterotrophs obtain the energy that they need to produce ATP. [5]

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References:

1. Image: diegograndi, 2023. *Beautiful Fluffy White Angora Rabbit*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/beautiful-fluffy-white-angora-rabbit-royalty-free-image/1804804966 [Accessed 30 April 2024]. SOURCE ADAPTED.

Table, graphs and pie charts: Bohao Zhao, Jiali Li, Xiyu Zhang, Zhiyuan Bao, Yang Chen and Xinsheng Wu, 2022. Characterisation and functional analysis of the WIF1 gene and its role in hair follicle growth and development of the angora rabbit. *World Rabbit Science* 30, pp.209–218. https://doi.org/10.4995/wrs.2022.17353. SOURCE ADAPTED.

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