AQA A Level

Thursday 5 June 2025

Afternoon (Time: 2 hours)

Biology

Unit: 7402/1

Paper 1

You must have:
Calculator, ruler

Instructions

- Use **black** ink or a ball-point pen.
- Answer **all** questions.
- Answer the questions in the spaces provided.
    - *There may be more space than you need*.
- Show all the steps in any calculations and state the units.

Information

- The total mark for this paper is 91.
- The marks for each question are shown in brackets.
    - *Use this as a guide as to how much time to spend on each question.*

Advice

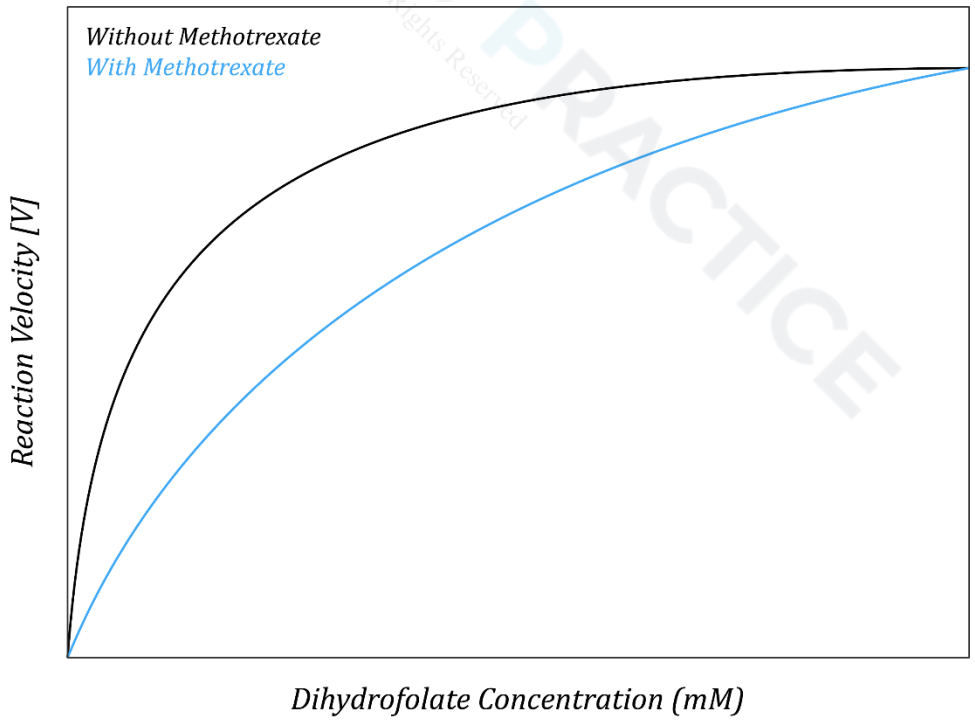
- Read each question carefully before you start to answer it.
- Write your answers neatly and in good English.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over →

1. Methotrexate is a drug that is used to inhibit the enzyme dihydrofolate reductase. Methotrexate is an example of a competitive inhibitor.

(a) Describe how a competitive inhibitor can reduce the rate of an enzyme-controlled reaction. **(3)**

Dihydrofolate reductase (DR) is involved in the synthesis of DNA nucleotides. A graph showing the inhibition of DR with methotrexate is shown below.



(b) Explain how the graph shows that methotrexate is a competitive inhibitor. **(1)**

A scientist decides to compare the rate of nucleotide synthesis with and without methotrexate. To do this he uses the following equation:

$$V = \frac{V_{max} \times [S]}{K_m + [S]}$$

Where: V_{max} = the maximum reaction velocity (120 mmol/min), K_m = the Michaelis constant (0.2 mM without methotrexate and 0.5 mM with methotrexate) and $[S]$ = the substrate concentration.

(c) Calculate the reaction velocity (V) for both scenarios (with and without methotrexate) when the dihydrofolate concentration is 0.1 mM. **(4)**

(d) Suggest how methotrexate might be used to treat certain types of cancers. **(3)**

(Total for Question 1 = 11 marks)

2. Photosynthesis is a critical process that occurs in the chloroplasts of leaf cells. This process converts light energy into chemical energy.

(a) Describe the structure of a chloroplast. **(2)**

Leaf cells are highly adapted to increase the efficiency of photosynthesis.

(b) Select **two boxes** describing adaptations that would increase the rate of photosynthesis. **(2)**

☒ **A** Thick cuticle on the upper surface of the leaf to minimize water loss during hot conditions.

☒ **B** High density of stomata on the upper surface of the leaf to increase gas exchange.

☒ **C** Presence of large vacuoles in leaf cells to store nutrients and water.

☒ **D** Increased chloroplast density in the palisade mesophyll cells to maximise light absorption.

☒ **E** Stomata on the lower surface of the leaf to reduce water loss while allowing gas exchange.

☒ **F** Narrow, needle-like leaves to reduce surface area exposed to sunlight.

Sunflower leaves are known for their high photosynthetic efficiency. During summer, a sunflower leaf can produce 8 μM of glucose per cm^2 of leaf surface per hour.

(c) Calculate the total amount of glucose produced by a sunflower leaf measuring 20 cm by 30 cm over a 12-hour period of peak sunlight exposure. **(2)**

The endosymbiotic theory suggests that chloroplasts were once bacteria that became part of early eukaryotic cells. A key piece of evidence for this theory is that the ribosomes found in chloroplasts are similar to those found in bacteria.

(d) Describe how a researcher could use ultracentrifugation to differentiate between the ribosomes found in chloroplasts and those found in the root cells of a plant. **(4)**

(Total for Question 2 = 10 marks)

3. Many species of rhino have seen their numbers decline due to poaching and habitat loss. In Indonesia, only 40 Sumatran rhinos (*Dicerorhinus sumatrensis*) remain.

(a) Suggest why the Sumatran rhino is likely to have very low genetic diversity. **(2)**

A team of conservationists is exploring the possibility of cross-breeding the Sumatran rhino with either the Indian rhino (*Rhinoceros unicornis*) or the Javan rhino (*Rhinoceros sondaicus*).

The table below shows details about the three different species of rhino.

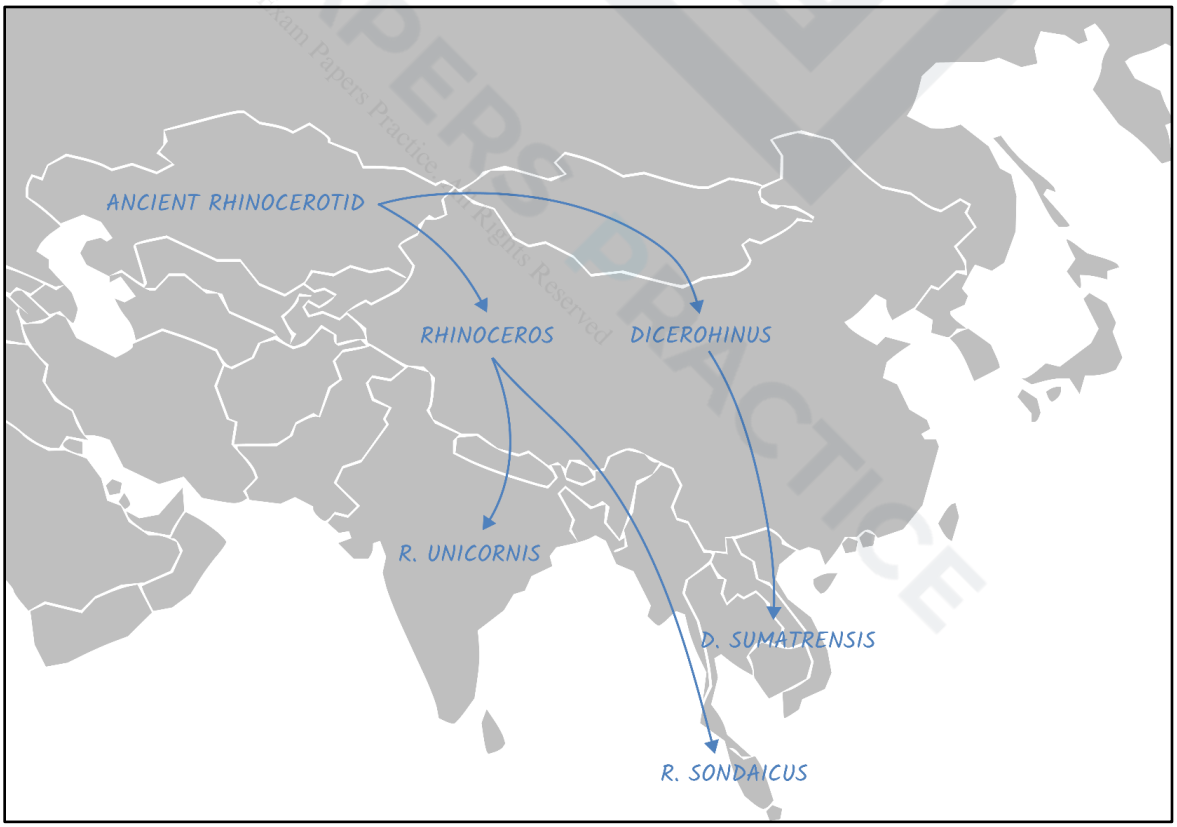
Species	Scientific Name	mtDNA Sequence	Population Size
Sumatran rhino	*Dicerorhinus sumatrensis*	ATG | CCC | TGA | GAC | CAT	40
Javan rhino	*Rhinoceros sondaicus*	ATG | CCC | AGC | GAC | CAT	80
Indian rhino	*Rhinoceros unicornis*	TGA | GGC | CTG | CGC | CAT	3,500

The team decide that the Indian rhino would be more suitable for cross-breeding.

(b) Evaluate this viewpoint. **(4)**

Ancient rhinocerotids, the ancestors of modern rhinos, once roamed over a landlocked Eurasia. Over millions of years these rhinocerotids diversified into several species including the Sumatran, Javan and Indian rhinos.

The evolutionary history of these rhinos is shown in the diagram below.



(c) Draw a simple phylogenetic tree to illustrate the evolutionary relationships between the Sumatran rhino, Javan rhino and Indian rhino. Your tree should reflect how these species diverged from their common ancestors in ancient Eurasia. **(3)**

The clearance of rainforests in Sumatra for palm oil plantations has significantly reduced plant biodiversity. The conservation team took a count of the numbers of six species of plant found in the Sumatran rainforest before and after land clearance took place.

Species	Count Before Clearance	Count After Clearance
Sumatran orchid	153	29
Stinking corpse lily	87	12
Sumatran pine	194	53
Tualang tree	121	28
Giant fern	176	45
Meranti tree	269	67

The conservation team used Simpson's index of biodiversity to identify the impact of land clearance.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

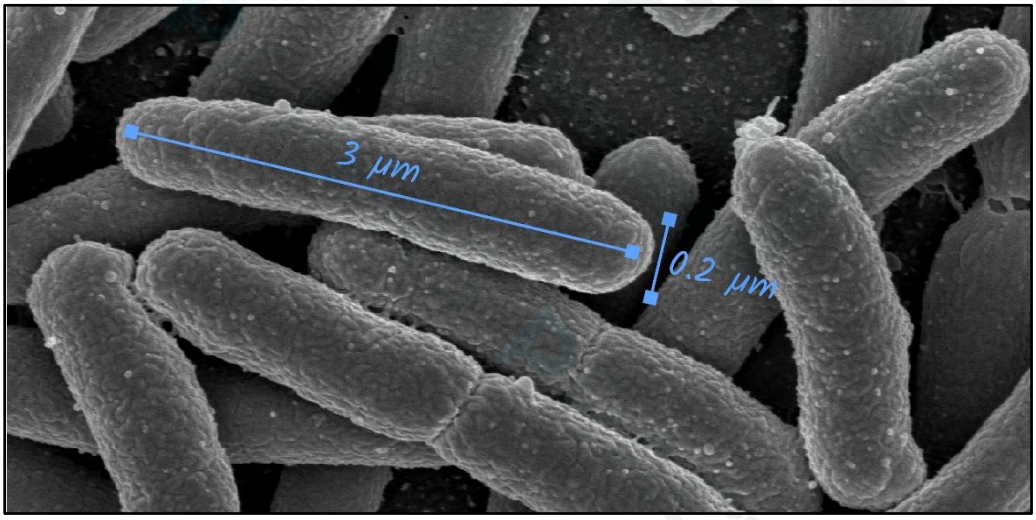
(d) Use Simpson's index to calculate the percentage decrease in biodiversity after land clearance has taken place. **(3)**

Deforestation not only reduces the total area of rainforests but also divides what remains into isolated patches. This is shown in the image below.

(e) Explain how forest fragmentation has contributed to the decline of Sumatran rhinos. **(2)**

(Total for Question 3 = 14 marks)

4. *Campylobacter jejuni* (*CJ*) is a rod-shaped bacteria that can cause vomiting and diarrhoea. A micrograph with some *CJ* bacteria is shown below.



This image was created by a scanning electron microscope (SEM).

(a) Explain why. **(2)**

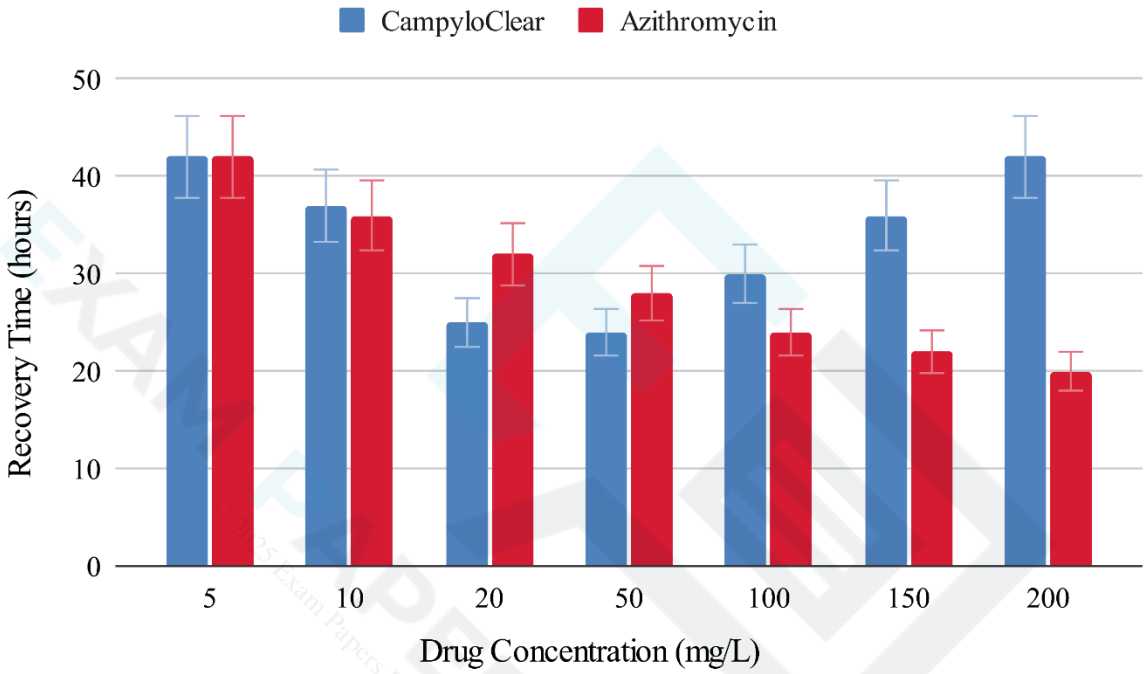
(b) Using the micrograph, calculate the volume of one *CJ* bacterium. **(4)**

The small intestine consists of trillions of bacteria and other microorganisms. It is thought that a healthy gut microbiome may help prevent infections from pathogens such as *CJ*.

(c) Suggest how the gut microbiome might help to prevent infections caused by *CJ*. **(2)**

A new antimicrobial called CampyloClear has been developed to treat patients with *CJ* infections.

CampyloClear is being tested at various concentrations to determine its efficacy compared to Azithromycin, a widely-used standard treatment. A graph of the results is shown below.



(d)

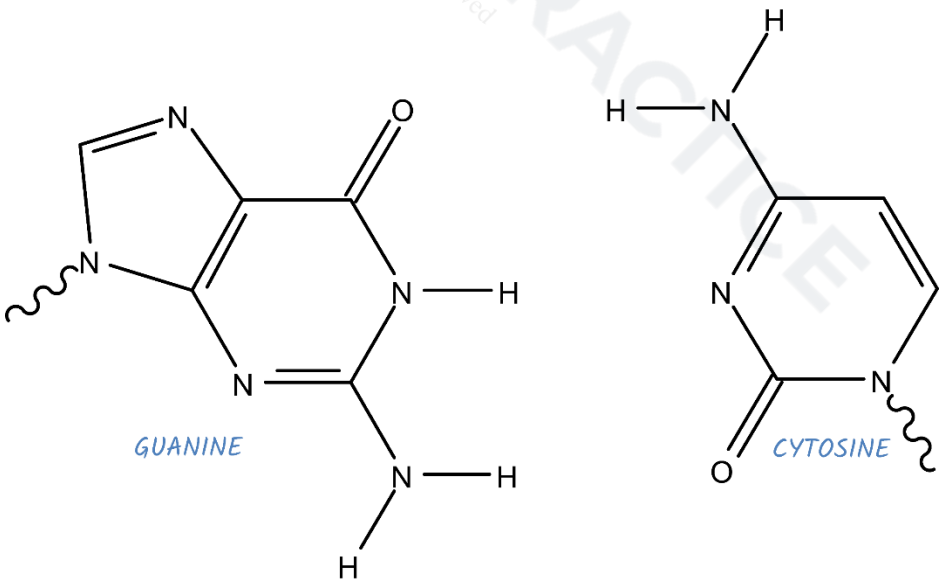
Evaluate the effectiveness of CampyloClear compared to Azithromycin. Do the results justify switching to CampyloClear as the new standard treatment? **(3)**

CampyloClear is revealed to be a monoclonal antibody.

(e) Explain how the data supports this statement. **(2)**

(Total for Question 4 = 13 marks)

5. The diagram below shows neighbouring guanine (G) and cytosine (C) nucleotides.



(a) Draw lines (---) to show that G and C undergo complementary base pairing. **(2)**

Guanine can be converted into guanosine triphosphate (GTP) inside the cell.

(b) Suggest a mechanism for the formation of GTP. **(2)**

GTP plays a crucial role at the start of translation. GTP provides the necessary energy to drive the assembly of an 'initiation complex' at the ribosome.

(c) Aside from GTP, list the other components present at the start of translation that are necessary for the formation of the initiation complex. **(2)**

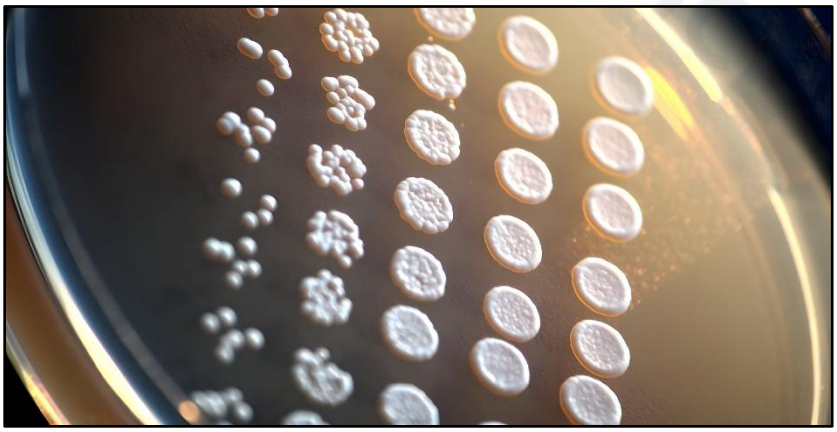
During translation, the rate at which peptide bonds are formed can vary depending on the concentration of GTP:

- At a GTP concentration of **50 mg/L**, peptide bonds form at a rate of **15 bonds per second**.
- At **100 mg/L**, the rate decreases **to 10 bonds per second**.
- At **200 mg/L**, the rate further decreases to **5 bonds per second**.

(d) Calculate the total number of peptide bonds formed in one hour at each of the given GTP concentrations. **(2)**

(e) Suggest why protein synthesis might be slower at higher GTP concentrations, despite the increased availability of GTP. **(3)**

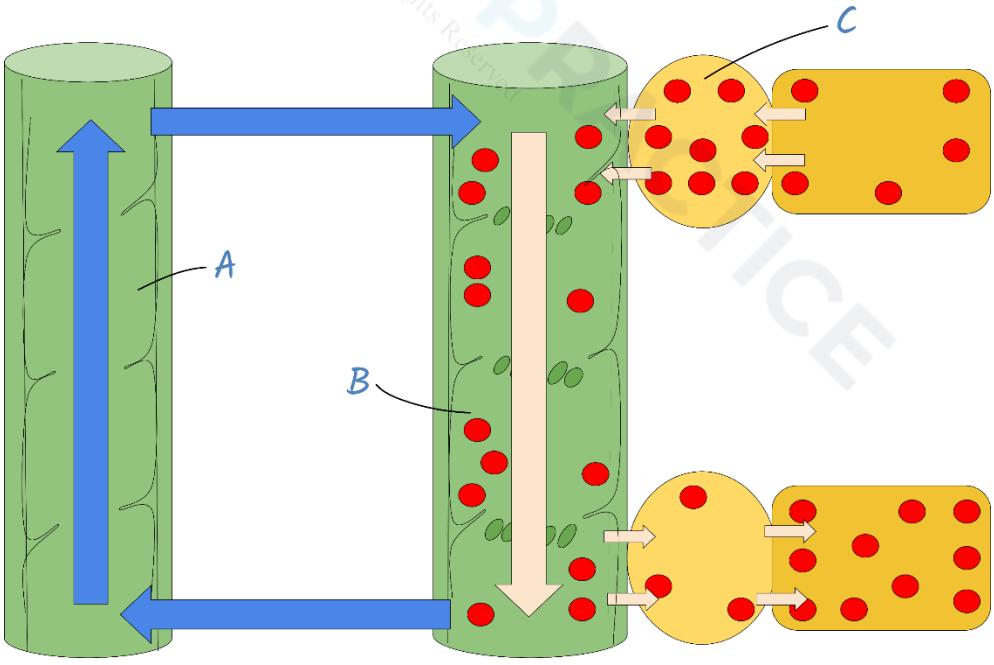
Yeast cells are prolific in producing and exporting various proteins. Colonies of one species of yeast, *Saccharomyces cerevisiae*, are shown in the image below.



(f) Explain how a researcher could use a biochemical test to quantitatively measure the rate of protein synthesis in yeast cells. **(4)**

(Total for Question 5 = 15 marks)

6. The mass transport system for a land plant is shown below.



(a) Name the structures labelled A, B and C. **(3)**

(b) Explain how this mass transport system ensures that a pressure gradient is maintained in structure B. **(4)**

A scientist is interested in exploring how a metabolic inhibitor might impact the rate of translocation within plants.

To facilitate this study, they decide to use aphids. Aphids are small insects which are equipped with sharp mouthparts capable of puncturing the bark of a tree.

An image of an aphid is shown on the next page.

(c) Design an experiment using aphids to measure the rate of sap flow in normal and inhibitor-treated trees. Suggest ways to ensure the results are valid. **(4)**

Plants store their sugar as starch.

(d) Give two reasons why starch is a good storage molecule in plants. **(2)**

(Total for Question 6 = 13 marks)

7. Answer the following questions fully.

(a) How does the structure of the phospholipid bilayer contribute to its function? **(5)**

(b) Describe how a dissociation curve illustrates haemoglobin's oxygen-binding properties. Explain why the curve has an 'S' shape. **(5)**

(c) Describe the process of atheroma formation within coronary arteries. Explain how this can lead to a heart attack. **(5)**

(Total for Question 7 = 15 marks)

TOTAL FOR PAPER = 91 MARKS