Haemoglobin Mutations

A Level

Table 1 shows the first seven amino acids of the β chain of haemoglobin and the corresponding 21 base pairs of DNA that code for these seven amino acids. The leftmost base pair is referred to as base pair 1.

Table 1

Amino acid sequence	Val	His	Leu	Thr	Pro	Glu	Glu
DNA sequence	CAC	GTG	GAC	TGA	GGA	CTC	CTC
	GTG	CAC	CTG	ACT	CCT	GAG	GAG

Table 2 shows the corresponding mRNA codons for a selection of amino acids.

Table 2

Amino acid	**mRNA codon(s)**
cysteine (Cys)	UGC, UGU
glutamic acid (Glu)	GAA, GAG
histidine (His)	CAC, CAU
leucine (Leu)	CUA, CUC, CUG, CUU
proline (Pro)	CCA, CCC, CCG, CCU
threonine (Thr)	ACA, ACC, ACG, ACU
valine (Val)	GUA, GUC, GUG, GUU
no amino acid (STOP)	UAA, UAG, UGA

Part A DNA strands

What is the name given to the **top** DNA strand (with the sequence "$\mathrm{CAC\ GTG}$...") in **Table 1**?

What is the name given to the **bottom** DNA strand (with the sequence "$\mathrm{GTG\ CAC}$...") in **Table 1**?

Part B Deletion of base pair 6

A single base pair deletion occurs at base pair 6 in the β haemoglobin DNA sequence shown in **Table 1**.

Enter the new amino acid sequence for the first three DNA base pair triplets.

Enter the amino acid sequence from left to right, with the first amino acid on the left.

[ ] – [ ] – [ ]

Items:

Cys **Glu** **His** **Leu** **Pro** **Thr** **Val** **STOP**

Part C Deletion of base pairs 7 to 9

In another cell, base pairs 7, 8, and 9 are deleted from the β haemoglobin DNA sequence shown in **Table 1**.

Enter the new amino acid sequence for the first four DNA base pair triplets.

Enter the amino acid sequence from left to right, with the first amino acid on the left.

____ – ____ – ____ – ____

Items:

Cys **Glu** **His** **Leu** **Pro** **Thr** **Val** **STOP**

Adapted with permission from CIE AS Level Biology, June 2017, Paper 2, Question 4b

Sucrose Reactions and Transport

A Level

Figure 1 shows how sucrose is broken down.

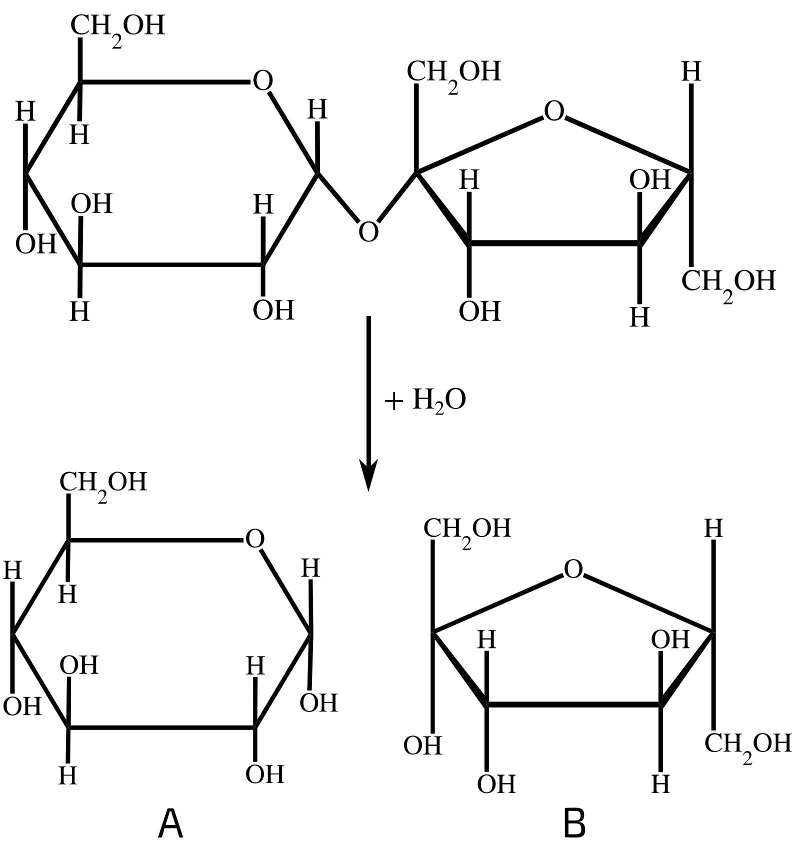

Figure 1: Sucrose breakdown. A sucrose molecule reacts with water to form two monosaccharides.

Part A Products

Name product **A** from the reaction shown in **Figure 1**.

Name product **B** from the reaction shown in **Figure 1**.

Part B Bond

Name the type of bond that is broken in the reaction shown in **Figure 1**.

Part C Reaction

State the type of reaction shown in **Figure 1**.

Part D Transport

Drag the items below into the correct order on the right to show how sucrose is transported from photosynthetic tissue in the leaves of plants to storage tissues in the roots.

Available items

- sucrose moves from sieve tube elements into companion cells by diffusion through plasmodesmata
- sucrose moves from companion cells into sieve tube elements by diffusion through plasmodesmata
- sucrose moves from mesophyll tissue into companion cells either by diffusion through plasmodesmata or by active transport
- the water potential in this region decreases, and so water moves in from surrounding tissues, increasing the hydrostatic pressure here
- liquid moves away from high pressure regions towards low pressure regions (where the water potential is higher due to low sucrose concentrations)
- sucrose moves from companion cells into other cells in the roots either by diffusion through plasmodesmata or by active transport

Adapted with permission from CIE AS Level Biology, June 2018, Paper 2, Question 2

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STEM SMART Biology Week 49

Albino Rabbits

A Level

The Hardy-Weinberg principle, represented by the equations below, can be used to estimate the frequency of alleles in a population.

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

$$p + q = 1$$

Albino rabbits have white fur as these individuals are unable to produce the pigment melanin. The ability to produce melanin is controlled by a gene with a dominant allele (**B**), resulting in brown fur, and a recessive allele (**b**), resulting in an albino.

Of the 60 rabbits in a pet shop, 45 are brown.

A student decided to use the Hardy-Weinberg principle to estimate the frequencies of the alleles in this group of rabbits.

Part A Hardy-Weinberg calculation

Using the Hardy-Weinberg equations, estimate the frequency of the **dominant** allele in this group.

Give your answer to 2 decimal places.

Part B Hardy-Weinberg conditions

Why was it not appropriate to use the Hardy-Weinberg principle to estimate the frequencies of alleles in this group of rabbits in the pet shop? Select all that apply.

- [ ] the number of rabbits is very small
- [ ] albinism is a mutation
- [ ] rabbits will regularly be leaving the pet shop (and new rabbits will be brought in)
- [ ] mating is likely to be random
- [ ] natural selection is likely to be occurring
- [ ] mating is **not** likely to be random

Adapted with permission from OCR A Level Biology A, June 2014, Control, Genomes and Environment, Question 6b

Gameboard:
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Moss Life Cycle

A Level

Mosses are small plants that live in damp conditions.

The life cycle of many mosses involves two multicellular stages: a gametophyte and a sporophyte.

The gametophyte contains haploid cells and produces sperm cells and egg cells.

The sporophyte contains diploid cells and produces haploid spores which can be spread easily through the air.

A spore germinates and grows into a gametophyte.

Figure 1 shows the life cycle of the moss *Funaria*.

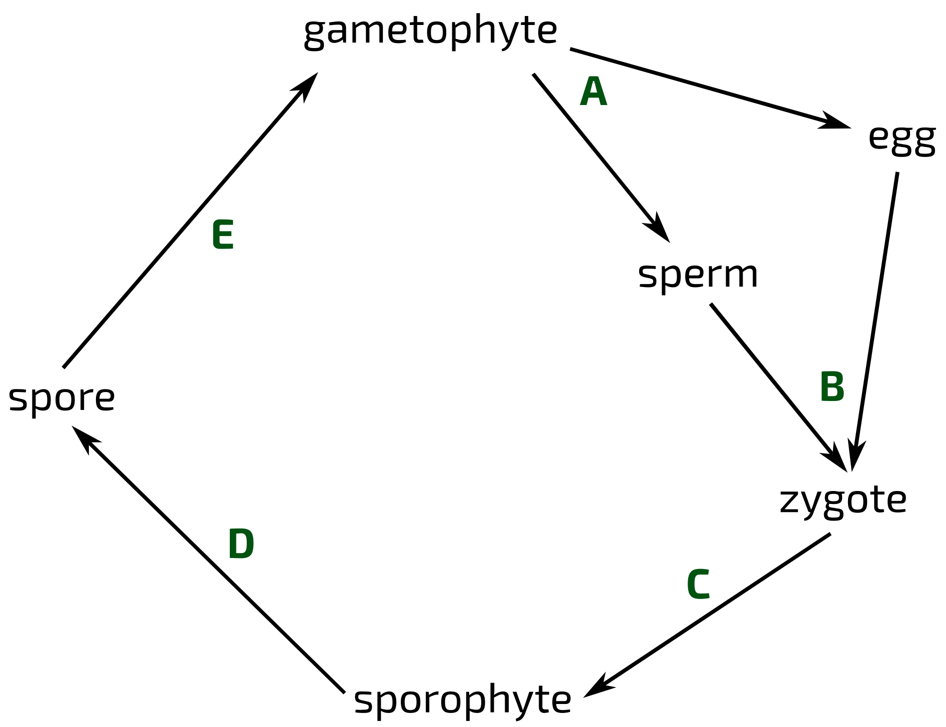

Figure 1: Life cycle of the moss *Funaria*. Letters A-E represent different cell processes.

Part A Meiosis & mitosis

Which arrow(s) in **Figure 1** represent(s) **meiosis**? Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E

Which arrow(s) in **Figure 1** represent(s) **mitosis**? Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E

Part B DNA strands

The haploid gametophyte of one species of *Funaria* contains 28 chromosomes per cell.

A single DNA molecule contains two strands.

Calculate the number of strands of DNA present in the nucleus of the zygote immediately before mitosis.

Adapted with permission from OCR A Level Biology A, November 2020, Biological diversity, Question 19c

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isaac Physics. You work it out.

Ecosystem Bacteria

A Level

C C C

Part A Bacterial species

Fill in the table below to show the locations of each type of bacterium in the nitrogen cycle and the reactions they perform.

Type of bacterium	Location	Reactant(s)	Product	Nitrogen is...
Rhizobium		N_2 and H^+ ions	NH_3	reduced
Nitrosomonas	soil			oxidised
Nitrobacter	soil		NO_3^-	
Denitrifying bacteria		NO_3^-		

Items:

soil **root nodules of legumes** **N_2 (nitrogen gas)** **NO_2^- (nitrites)** **NH_4^+ (ammonium ions)** **oxidised** **reduced**

Part B Nitrogenase

Nitrogen fixation is an important part of the nitrogen cycle.

The rate of nitrogen fixation is reduced by the presence of oxygen.

Rhizobium uses the enzyme nitrogenase to fix atmospheric nitrogen. H_2 can bind instead of N_2 to the binding site shown for N_2.

Figure 1 shows a simplified representation of the structure of nitrogenase.

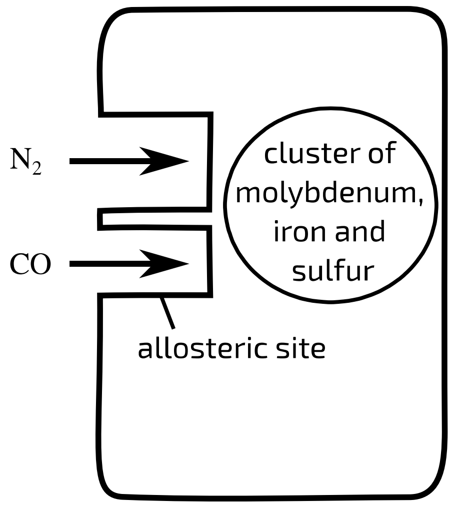

Figure 1: Nitrogenase enzyme structure.

The reaction that nitrogenase catalyses is:

$$N_2 + 8\,H^+ + 8\,e^- + 16\,\text{ATP} \rightarrow 2\,NH_3 + H_2 + 16\,\text{ADP} + 16\,P_i$$

Based on the information above, which of the following statements about nitrogenase are correct? Select all that apply.

- [ ] H_2 may act as a **competitive** inhibitor
- [ ] H_2 may act as a **non-competitive** inhibitor
- [ ] CO may act as a **competitive** inhibitor
- [ ] CO may act as a **non-competitive** inhibitor
- [ ] the cluster of molybdenum, iron and sulfur is a prosthetic group
- [ ] the cluster of molybdenum, iron and sulfur is part of the nitrogenase enzyme's primary structure

Part C Leghaemoglobin

Leghaemoglobin is a molecule, found in leguminous plants, that improves the performance of nitrogenase. It has very similar properties to mammalian haemoglobin.

Which of the following statements could explain how leghaemoglobin improves the performance of the nitrogenase enzyme? Select all that apply.

- [ ] leghaemoglobin stops hydrogen from binding to the active site of nitrogenase
- [ ] leghaemoglobin stops carbon monoxide from binding to the allosteric site of nitrogenase
- [ ] leghaemoglobin acts as an enzyme to convert nitrates to nitrogen
- [ ] leghaemoglobin stops oxygen from reacting with nitrogenase
- [ ] leghaemoglobin acts as an enzyme to convert ammonium to nitrates
- [ ] leghaemoglobin increases the efficiency of aerobic respiration in the plant cells

Part D Decomposition

Many species of bacteria act as decomposers within ecosystems by breaking down organic material.

Scientists analysed the energy flow within a grassland ecosystem.

They estimated that the energy in the decomposers' trophic level was $950\,000\,\mathrm{J\,m^{-2}\,yr^{-1}}$.

The energy within the producers' trophic level was $800\,\%$ greater than that of the decomposers.

Calculate the energy in the producers' trophic level in $\mathrm{kJ\,m^{-2}\,yr^{-1}}$. Give your answer to 3 significant figures.

Calculate the percentage efficiency of the energy transfer from producers to decomposers. Give your answer to 2 significant figures.

Adapted with permission from OCR A Level Biology A, June 2017, Unified Biology, Question 4

Gameboard:

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Heart Pressure Changes

A Level

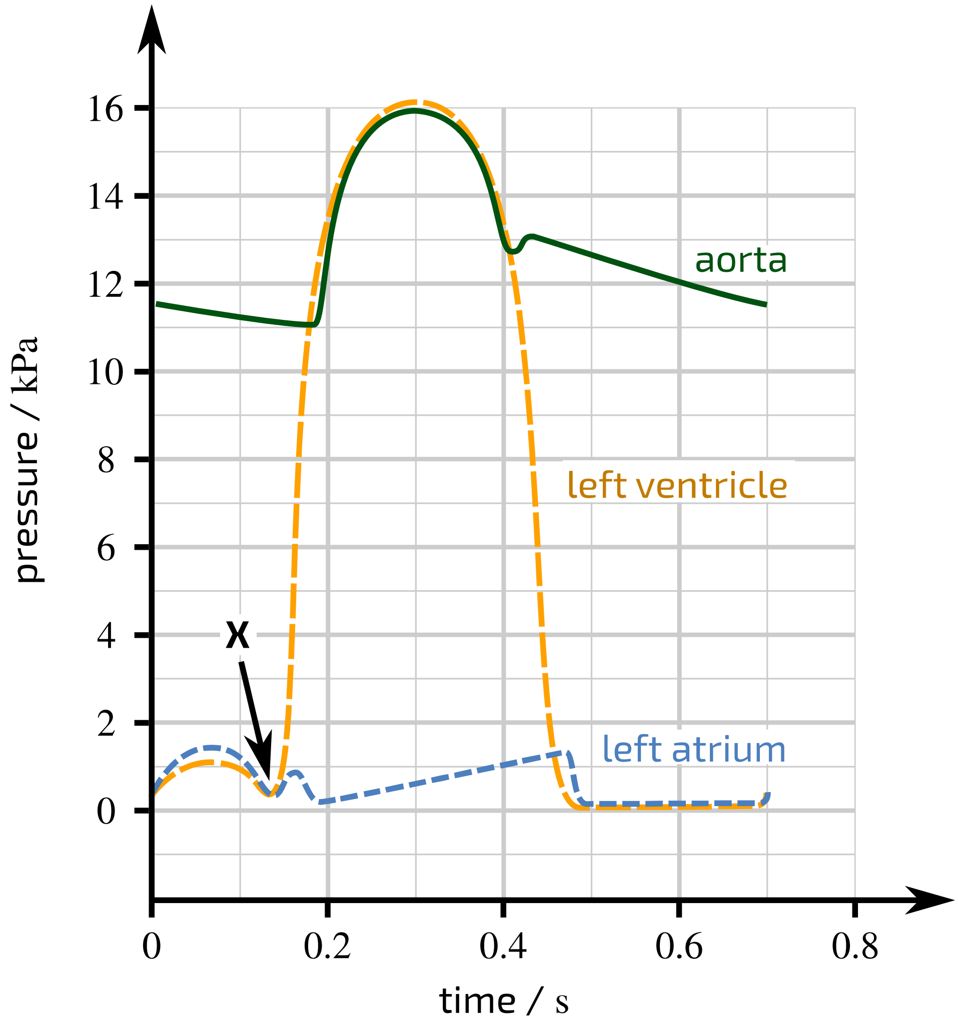

Figure 1: Pressure changes in the left atrium, left ventricle, and aorta during a single cardiac cycle.

Part A $0\,\mathrm{s}$ to point X

Which of the following statements are true of the period from $0\,\mathrm{s}$ to point **X** in **Figure 1**? Select all that apply.

- [ ] atrial systole is occuring
- [ ] atrial diastole is occuring
- [ ] pressure rises in the left atrium because it is contracting
- [ ] pressure rises in the left atrium because blood is moving into it from the vena cava
- [ ] pressure rises in the left ventricle because it is contracting
- [ ] pressure rises in the left ventricle because blood is being pumped into it from the left atrium

Part B Point X to $0.4\,\mathrm{s}$

Which of the following statements are true of the period from point **X** to $0.4\,\mathrm{s}$ in **Figure 1**? Select all that apply.

- [ ] atrial systole is occuring
- [ ] ventricular systole is occuring
- [ ] pressure rises in the left ventricle because it is contracting
- [ ] pressure rises in the aorta because blood is being pumped into it from the left ventricle
- [ ] pressure rises in the left atrium because it is contracting
- [ ] pressure rises in the left atrium because blood is moving into it from the vena cava

Part C Heart rate

Calculate the heart rate of the individual shown in **Figure 1**.

Give your answer to 2 significant figures.

Part D Aortic pressure

Calculate the percentage increase from minimum to maximum pressure in the aorta of the individual shown in **Figure 1**.

Give your answer to 2 significant figures.

Part E Valves

Name the type of valve that closes at point **X** in **Figure 1**.

Adapted with permission from OCR A Level Biology A, June 2019, Biological processes, Question 16