

Examiners' Report

June 2025

Int Advanced Level Biology WBI12 01

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June 2025

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Introduction

This paper tested the knowledge, understanding and application of material from the topics 'Cell structure, Reproduction and Development' and 'Plant Structure and Function, Biodiversity and Conservation'.

The range of questions provided ample opportunity for students to demonstrate their grasp of these topics and apply their knowledge to novel contexts.

The questions on this paper yielded a wide range of responses and some very good answers were seen.

The paper appears to have worked very well with all questions achieving the full spread of marks.

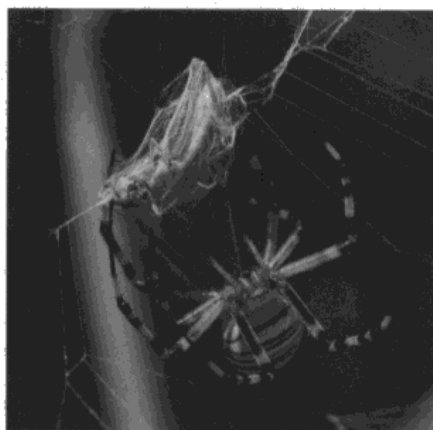
Question 1(a)

This question asked candidates to state what is meant by the term organ system.

Most students could give a correct definition of this term, following the style of mark schemes for organ and tissue on previous papers.

However, some candidates gave the definition of an organ and not an organ system.

- 1 The photograph shows a grasshopper being caught in a web by a wasp spider.



(Source: © Nicola Ferrari / Alamy Stock Photo)

The spider uses extracellular enzymes from its digestive system to digest parts of the grasshopper.

- (a) The digestive system is an organ system.

State what is meant by the term **organ system**.

(1)

Group of tissues working together, for performing specific function.



This is an example of a common incorrect answer, where the candidate gave a definition of an organ and not an organ system.

- 1 The photograph shows a grasshopper being caught in a web by a wasp spider.



(Source: © Nicola Ferrari / Alamy Stock Photo)

The spider uses extracellular enzymes from its digestive system to digest parts of the grasshopper.

- (a) The digestive system is an organ system.

State what is meant by the term **organ system**.

(1)

It is a group of organs working together to perform a specific function



An example of a correct answer.

Question 1(b)iii

This question asked candidates to calculate the magnification of the photograph.

Candidates were provided with two measurements, one in cm and the other in μm .

Although most candidates could recall and manipulate the relevant equation correctly, fewer candidates could correctly convert units, with a significant number converting μm to either nm or pm instead of cm or mm.

Some candidates did not take careful note that the measurement was in cm and not mm when converting one of the measurements.

Some candidates did not take careful note of the instruction to give their answer to two significant figures and therefore were limited to 1 mark.

- (iii) A student measured the width of one part of the organelle in the photograph as 3.2 cm.

The actual width was 0.95 μm .

Calculate the magnification of the photograph.

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

(2)

$\times 3.31$

(Total for Question 1 = 6 marks)



This candidate has lost any possibility of gaining marking point one as they have not shown their working. Their answer is not given to two significant figures.



Always show your working in calculations.

- (iii) A student measured the width of one part of the organelle in the photograph as 3.2 cm.

The actual width was 0.95 μm .

Calculate the magnification of the photograph.

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

$$3.2 \text{ cm} = 32 \text{ mm} = 32000 \mu\text{m} \quad (2)$$

$$\begin{aligned} \text{magnification} &= \frac{\text{actual}}{\text{image}} = \frac{\text{image}}{\text{actual}} \\ &= \frac{32000}{0.95} = \times 33684 \end{aligned}$$

$$\times 33684$$

(Total for Question 1 = 6 marks)



This candidate has correctly calculated the magnification, but loses a mark as their answer is not given to two significant figures.



Always reread the question after you have done the calculation to check how you should present your answer.

- (iii) A student measured the width of one part of the organelle in the photograph as 3.2 cm.

The actual width was 0.95 μm .

$$\mu\text{m} \times 10^{-3} \text{ mm} \times 10^{-1} \text{ cm}$$

Calculate the magnification of the photograph.

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

(2)

$$\begin{aligned} M &= \frac{I}{A} \\ &= \frac{3.2 \times 10^4 \mu\text{m}}{0.95 \mu\text{m}} \\ &= 33684.2 \\ &= \underline{\underline{3.4 \times 10^4}} \end{aligned}$$

$$\times 3.4 \times 10^4$$

(Total for Question 1 = 6 marks)



An example of a correct answer which gained full marks.

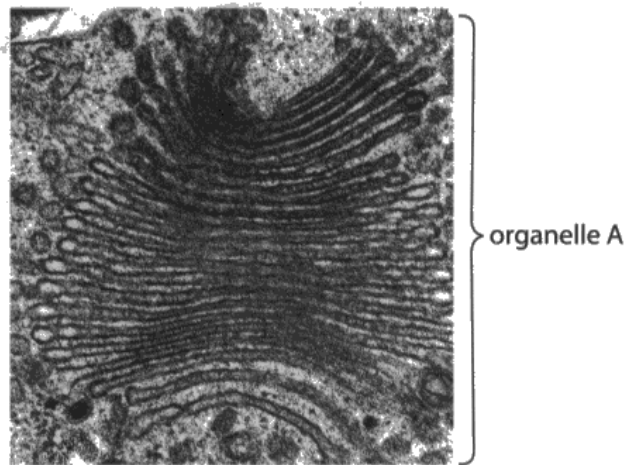
Question 1(b)i-ii

Candidates were given an electron microscope of an organelle involved in the formation of extracellular enzymes. The first part of the question assessed the skill of being able to recognise the organelle in the photograph.

Most candidates were able to recognise the Golgi apparatus, but there were a significant number who thought it was the rough endoplasmic reticulum or the smooth endoplasmic reticulum.

The second part of the question assessed the knowledge of the function of the Golgi apparatus. Most candidates could describe the role in protein modification. However fewer candidates could correctly describe the role of the Golgi apparatus in packaging the enzymes into a secretory vesicle. Some candidates described the movement of the vesicle to the cell surface membrane, without describing how the enzyme had entered the vesicle.

- (b) The photograph shows an organelle involved in the formation of extracellular enzymes, as seen using an electron microscope.



(Source: © Science Photo Library)

- (i) Name organelle A, shown in the photograph.

(1)

Golgi bodies

- (ii) Describe the role of **this** organelle in the formation and transport of extracellular enzymes.

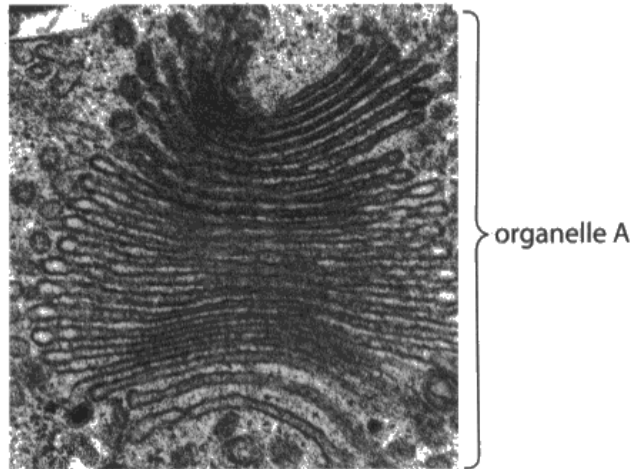
(2)

Golgi bodies is responsible for modification of enzyme (protein) by adding a carbohydrate or a lipid to protein, and packaging protein (enzyme) into a vesicle to be secreted by exocytosis outside of the cell.



This response gained full marks, for correctly identifying the Golgi body and then describing the role of this organelle in both the formation and transport of extracellular enzymes.

- (b) The photograph shows an organelle involved in the formation of extracellular enzymes, as seen using an electron microscope.



(Source: © Science Photo Library)

- (i) Name organelle A, shown in the photograph.

(1)

Golgi body

- (ii) Describe the role of **this** organelle in the formation and transport of extracellular enzymes.

(2)

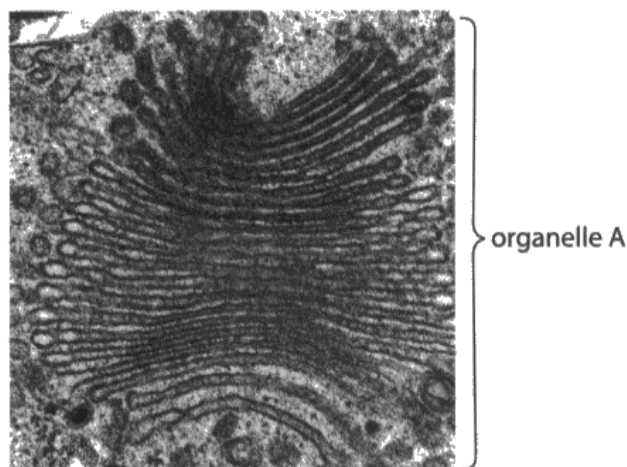
~~protein made~~

protein modification and form tertiary structure protein with
~~and transport~~ hydrogen bond within polypeptide chains
transport modified protein fuse with cell membrane
Vesicles transport protein out of cell by exocytosis



This response gained two of the possible three marking points. They have correctly identified the organelle and described the role in the formation of the extracellular enzymes. However, they have not described the role of the organelle in packaging the enzymes into the secretory vesicle.

- (b) The photograph shows an organelle involved in the formation of extracellular enzymes, as seen using an electron microscope.



(Source: © Science Photo Library)

- (i) Name organelle A, shown in the photograph.

(1)

Golgi apparatus

- (ii) Describe the role of **this** organelle in the formation and transport of extracellular enzymes.

(2)

*Golgi apparatus is an wibe-like protein that transfer enzymes
Is involved in the formation of extracellular enzymes*



This candidate has gained one mark for correctly identifying the organelle from the photograph. They have not described the role of this organelle.

Question 2(b)ii

This question asked candidates to give the name and function of two structures from the prokaryotic cell diagram.

Most candidates could correctly give the name and function of the flagellum, with some lovely, detailed answers given. However, a few responses were seen which named structure X as a tail, which is not appropriate terminology for IAL Biology.

The majority of candidates could identify the pili, with some lovely, detailed answers given.

(ii) Give the name and function of structure X and structure Y.

(2)

Name of structure X

Tail

Function

Movement of the cell

Name of structure Y

Function

Exchanging genetic information (Plasmid)



This response was awarded 0 marks. Although the candidate knew the function of structure X, the name of tail was not creditworthy. The specification uses the term flagellum. The candidate also knew the function of structure Y, but no mark could be awarded due to the lack of a correct name.



Use appropriate terminology from the specification.

(ii) Give the name and function of structure X and structure Y.

(2)

Name of structure X

Flagellum

Function

Allows movement of the prokaryotic cell

Name of structure Y

Function



This response was awarded one mark for the correct name and function of structure X.

(ii) Give the name and function of structure X and structure Y.

(2)

Name of structure X

Flagellum.

Function

It is responsible for movement of this prokaryotic cell.

Name of structure Y

Pili.

Function

They are responsible for attaching with other cell or other surface.



This response scored full marks.

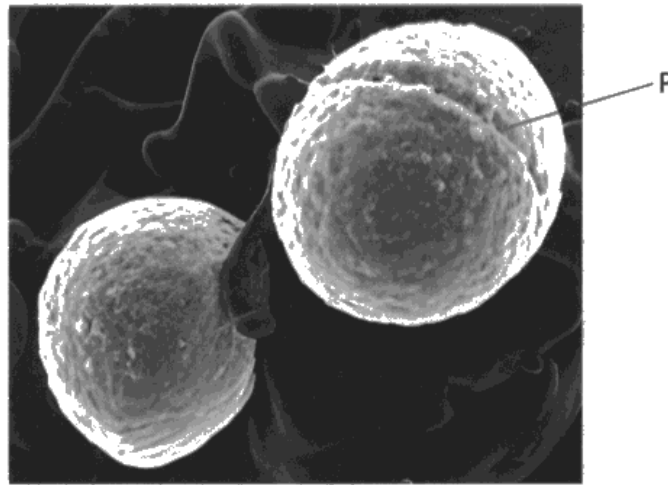
Question 2(c)i

This question asked candidates to state what is meant by the term resolution.

Many candidates understood this term and gained the mark.

However, a significant number of students confused resolution with either the term magnification or the term focus.

- (c) The photograph shows two prokaryotic cells, as seen using an electron microscope.



(Source: © BSIP SA / Alamy Stock Photo)

- (i) The electron microscope had a resolution of 2 nm.

State what is meant by the term **resolution**.

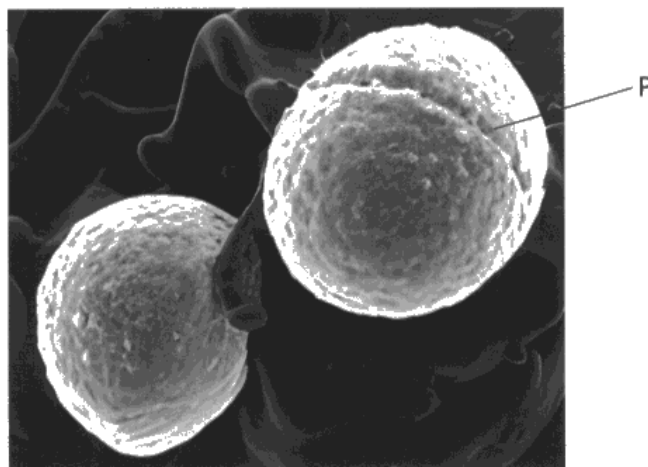
(1)

how close 2 different things can be without being seen as 1



This is a creditworthy answer for one mark.

- (c) The photograph shows two prokaryotic cells, as seen using an electron microscope.



(Source: © BSIP SA / Alamy Stock Photo)

- (i) The electron microscope had a resolution of 2 nm.

State what is meant by the term **resolution**.

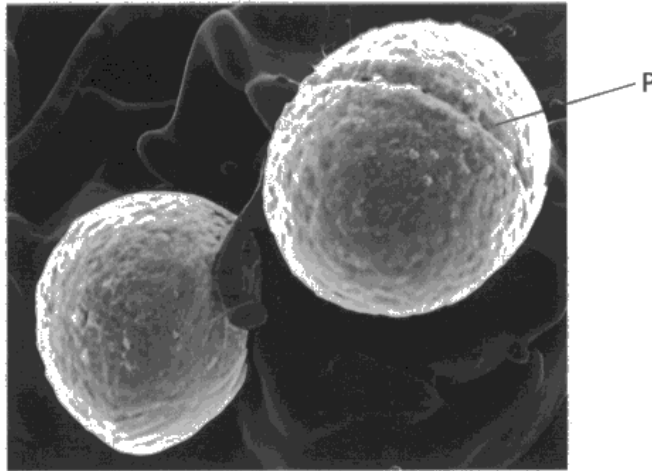
(1)

The minimum distance needed between 2 objects to appear as separate objects, which with this electron microscope is 2 nm



A correct answer for one mark.

- (c) The photograph shows two prokaryotic cells, as seen using an electron microscope.



(Source: © BSIP SA / Alamy Stock Photo)

- (i) The electron microscope had a resolution of 2 nm.

State what is meant by the term **resolution**.

(1)

The quality and sharpness of an image

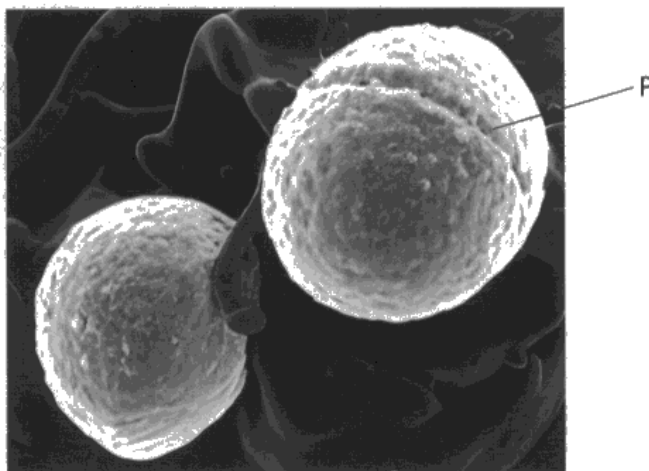


This is an example of a common incorrect response.



Make sure you understand the meanings of terminology used in the specification.

- (c) The photograph shows two prokaryotic cells, as seen using an electron microscope.



(Source: © BSIP SA / Alamy Stock Photo)

- (i) The electron microscope had a resolution of 2 nm.

State what is meant by the term **resolution**.

(1)

How much bigger we see an image based on its actual size



This is an example of a common incorrect response.

Question 2(c)ii

This question asked candidates to calculate the volume of cell P and give their answer to two decimal places.

Many candidates were able to use the provided formula to give the correct answer to two decimal places.

Some candidates could calculate the volume but did not give their answer to two decimal places.

Unfortunately, a significant number of candidates did not use the provided formula correctly. Some used the diameter measurement instead of the radius. Some did r^2 instead of r^3 .

(ii) The cell labelled P has a diameter of $0.60\text{ }\mu\text{m}$.

Calculate the volume of cell P.

Use the formula:

$$V = \frac{4}{3} \pi r^3$$

Give your answer to **two** decimal places.

(2)

$$V = \frac{4}{3} \pi (0.30)^3 = 0.11\text{ }\mu\text{m}^3$$

Answer 0.11 μm^3

(Total for Question 2 = 8 marks)



An example of a correct answer which scored 2 marks.

(ii) The cell labelled P has a diameter of $0.60\text{ }\mu\text{m}$.

Calculate the volume of cell P.

Use the formula:

$$V = \frac{4}{3}\pi r^3$$

Give your answer to **two** decimal places.

(2)

Answer 0.90 μm^3

(Total for Question 2 = 8 marks)



A common incorrect answer.



Always show your working in calculations.

(ii) The cell labelled P has a diameter of $0.60\text{ }\mu\text{m}$.

Calculate the volume of cell P.

Use the formula:

$$V = \frac{4}{3}\pi r^3$$

Give your answer to **two** decimal places.

(2)

$$\begin{aligned} d &= 0.6 \\ r &= 0.3 \\ v &= \frac{4}{3}(\pi)(0.3)^2 \\ &= 0.3769911184 \end{aligned}$$

Answer 0.38 μm^3

(Total for Question 2 = 8 marks)



Although this candidate correctly used the radius value in their calculation, they have written r^2 instead of r^3 .

Question 3(b)i

This question asked candidates to name the stage of meiosis when crossing over of chromatids occurs.

Most candidates knew that crossing over occurs in prophase I, however some candidates wrote prophase unqualified.

(b) There is genetic diversity in the passion flower population.

Two causes of genetic diversity in this population are mutations and crossing over of non-sister chromatids on homologous chromosomes.

(i) Name the stage of meiosis when crossing over of chromatids occurs.

(1)

~~prophase~~ prophase I



An example of a correct response.

(b) There is genetic diversity in the passion flower population.

Two causes of genetic diversity in this population are mutations and crossing over of non-sister chromatids on homologous chromosomes.

(i) Name the stage of meiosis when crossing over of chromatids occurs.

(1)

metaphase



This was a common incorrect answer.

(b) There is genetic diversity in the passion flower population.

Two causes of genetic diversity in this population are mutations and crossing over of non-sister chromatids on homologous chromosomes.

(i) Name the stage of meiosis when crossing over of chromatids occurs.

(1)

Prophase



As there are two prophase stages in meiosis, candidates needed to be clear which prophase stage they were referring to.

Question 3(b)ii

This question asked candidates to describe two other processes that can give rise to genetic variation in the offspring of passion flowers.

Some candidates did not take careful note of the word 'other' in the question. This referred to the previous page in the question paper where they were told that crossing over and mutation were two causes of genetic diversity.

Most correct answers centred around independent assortment of chromosomes in metaphase or random fertilisation. However, some mentioned the process of independent assortment unqualified, without correct reference to alleles, chromosomes or chromatids.

Some responses were seen which correctly described how epigenetic modification could give rise to genetic variation.

(ii) Describe **two** other processes that can give rise to genetic variation in the offspring of the passion flower.

(2)

1 mutation causing change in base sequence of DNA

2 Random assortment of chromosome above and below equator of cell giving new combinations of chromosome in each daughter cell



This response gained marking point one only. They have given mutation which was not creditworthy as it was mentioned as a cause of genetic diversity on the previous page in the question paper.

(ii) Describe **two** other processes that can give rise to genetic variation in the offspring of the passion flower.

(2)

1 independent assortment of homologous chromosomes during metaphase I

2 random fertilization as the male gamete that reaches the female gamete ~~are~~^{is} genetically different than the rest



This response gained marking points one and three.

Question 3(b)iii

This question asked candidates to recall the equation for heterozygosity index which is listed in the specification content.

Many candidates found this challenging.

A wide variety of answers were seen, including Hardy Weinberg equations, Index of Diversity equations and mitotic index equations.

A common error made by candidates when recalling the heterozygosity index equation was to divide the number of heterozygotes by the total number of species in the population.

- (iii) The heterozygosity index is a way of measuring the genetic diversity in a population.

Write an equation for the heterozygosity index.

$$\text{heterozygosity index} = \frac{\text{number of heterozygote individuals in the population}^{(1)}}{\text{total number of individuals in the population}}$$



This response scored one mark.

- (iii) The heterozygosity index is a way of measuring the genetic diversity in a population.

Write an equation for the heterozygosity index.

(1)

$$p^2 + 2pq + q^2 = 0$$



A common incorrect answer.



Learn equations given in the specification, including in the mathematical skills section.

- (iii) The heterozygosity index is a way of measuring the genetic diversity in a population.

Write an equation for the heterozygosity index.

(1)

$$\frac{\text{number of heterozygotes}}{\text{number of all chromosomes}}$$



This equation has an incorrect denominator and scored 0 marks.

- (iii) The heterozygosity index is a way of measuring the genetic diversity in a population.

Write an equation for the heterozygosity index.

(1)

$$\text{heterozygosity index} = \frac{\text{number of heterozygous individuals}}{\text{number of individuals in the population}} \times 100$$



The inclusion of x100 prevented the awarding of the mark.

Question 3(c)

This question asked candidates to explain how seeds would be selected for storage in a seed bank.

It is important to read the question carefully. This question centred on selection of seeds, not preparation of seeds for storage. A significant number of candidates gave answers which did not answer the question.

Some candidates knew that seeds would be x-rayed, but did not explain why this could lead to selection of some seeds and not others.

(c) Seeds from plant species are stored in seed banks.

Explain how seeds would be selected for storage in a seed bank.

(2)

The seeds ~~don't~~ treated before select to provide no disease in the seeds; seeds also select selected from ~~different plants~~ plants from different regions.

(Total for Question 3 = 7 marks)



This response did not gain any marks. Although the candidate understands that seeds should be selected from plants in different regions, they have not explained why. The comment about treatment of seeds was not creditworthy.

(c) Seeds from plant species are stored in seed banks.

Explain how seeds would be selected for storage in a seed bank.

(2)

- Select large number of seeds
- Select seeds from different passion flowers, from different countries to increase genetic diversity
- Seeds are x-rayed to check for embryo viability

(Total for Question 3 = 7 marks)



This response gained two marks. They have explained why a large number of seeds should be selected from different plants/countries and explained why seeds should be x-rayed.

(c) Seeds from plant species are stored in seed banks.

Explain how seeds would be selected for storage in a seed bank.

(2)

Seeds from different plants are selected and stored because this would increase the genetic variation and some important alleles are protected.

(Total for Question 3 = 7 marks)



This response gained marking point one only.



Use the number of marks as a guide to how many points you should make.

(c) Seeds from plant species are stored in seed banks.

Explain how seeds would be selected for storage in a seed bank.

(2)

Select a large amount of seeds

X-ray the seeds to confirm embryo viability

Sterilise the seeds using ethanol soaked cotton to kill bacteria

Store the seeds in a cold, dry environment to prevent germination and to denature bacterial enzymes

(Total for Question 3 = 7 marks)



This answer did not gain marking point one as there was no accompanying explanation. Marking point two was awarded. The candidate has given irrelevant information regarding preparation of the seeds and storage which was not creditworthy.



Check to see if your points are answering the question you have been asked.

Question 4(a)i

This question provided candidates with a bar chart showing the mean percentage of cellulose and lignin in bamboo plants of different ages.

Candidates were asked to calculate the ratio of cellulose to lignin for a one-year-old bamboo plant. The answer line had ':1' at the end as a guide to candidates of how to present their ratio.

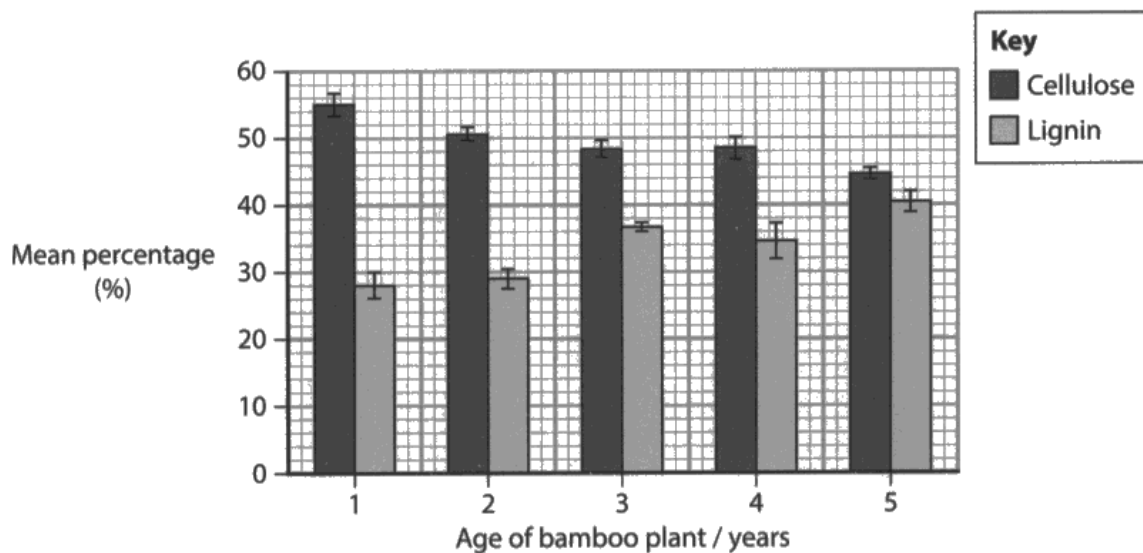
It was important that candidates took careful note of the order of the molecules in the question when calculating the ratio. A minority of candidates gave the ratio of lignin to cellulose which was not creditworthy.

Some candidates ignored the ':1' at the end of the answer line and as a result gave a ratio that

was not acceptable. Fractions are not an acceptable ratio format.

- (a) Cellulose and lignin contribute to the high tensile strength of bamboo.

The graph shows the mean percentage of cellulose and lignin in bamboo plants of different ages.



(Source: adapted from <https://www.mdpi.com/2073-4360/12/1/187>)

- (i) Calculate the ratio of cellulose to lignin for a one-year-old bamboo plant.

(1)

$$\frac{55}{28} = 1.96 \approx 2$$

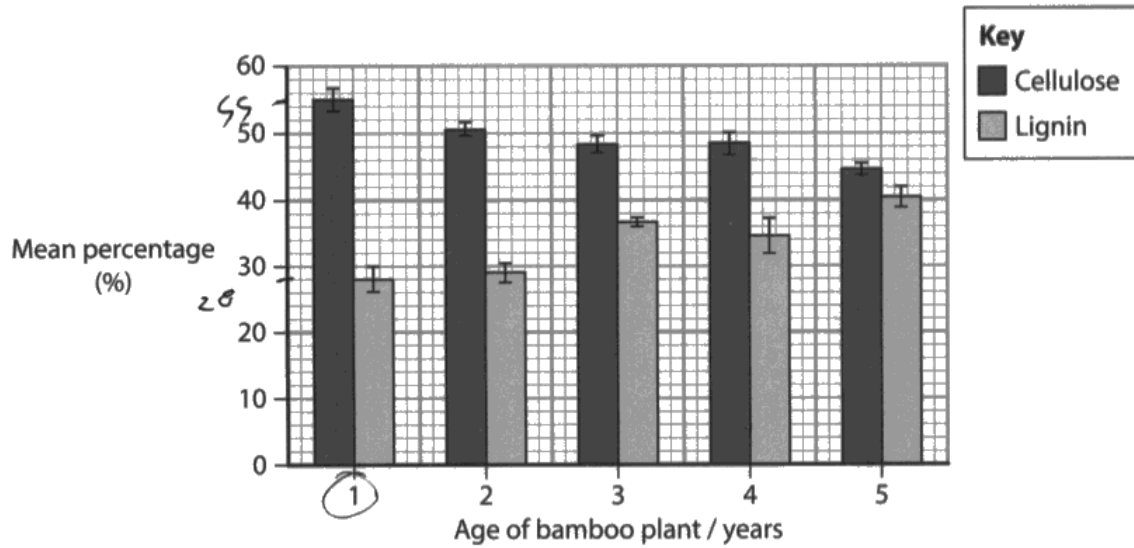
.....2.....:1



A correctly rounded answer of 2:1 was awarded one mark.

- (a) Cellulose and lignin contribute to the high tensile strength of bamboo.

The graph shows the mean percentage of cellulose and lignin in bamboo plants of different ages.



(Source: adapted from <https://www.mdpi.com/2073-4360/12/1/187>)

- (i) Calculate the ratio of cellulose to lignin for a one-year-old bamboo plant.

(1)

SS : 28

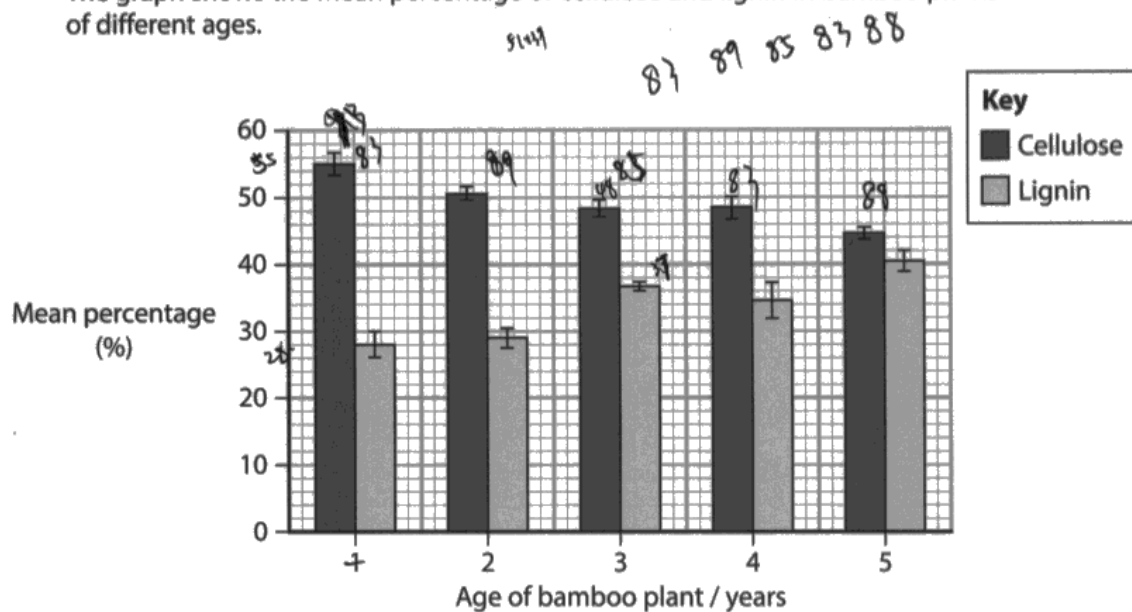
1.96 : 1



A correct answer scored one mark.

(a) Cellulose and lignin contribute to the high tensile strength of bamboo.

The graph shows the mean percentage of cellulose and lignin in bamboo plants of different ages.



(Source: adapted from <https://www.mdpi.com/2073-4360/12/1/187>)

(i) Calculate the ratio of cellulose to lignin for a one-year-old bamboo plant.

(1)

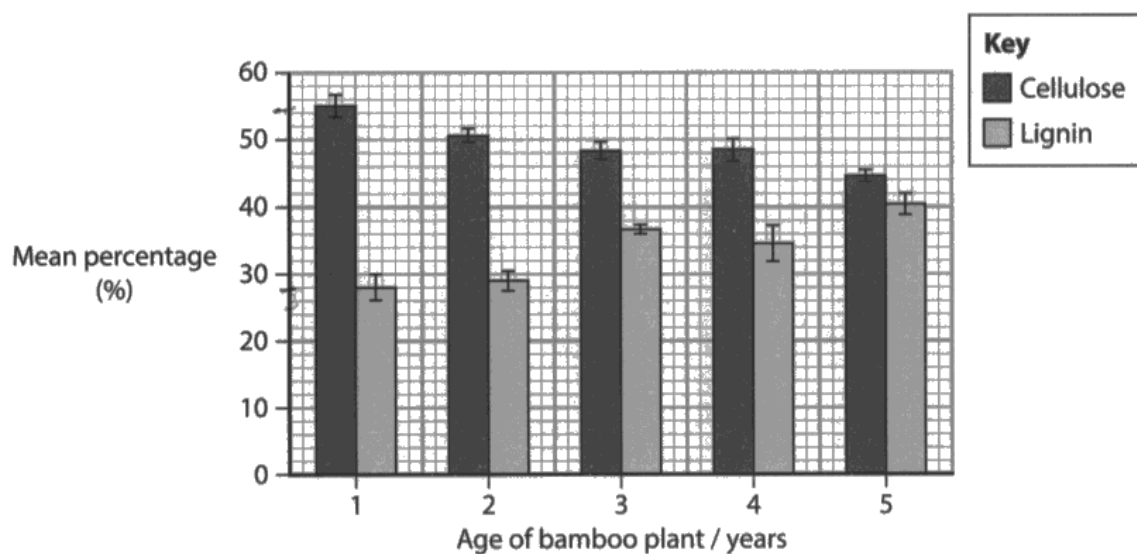
$$\frac{55}{28} : 1$$



Fractions are not an acceptable format for a ratio.

(a) Cellulose and lignin contribute to the high tensile strength of bamboo.

The graph shows the mean percentage of cellulose and lignin in bamboo plants of different ages.



(Source: adapted from <https://www.mdpi.com/2073-4360/12/1/187>)

(i) Calculate the ratio of cellulose to lignin for a one-year-old bamboo plant.

(1)

$$\frac{28}{55} = 0.509$$

0.51 : 1



This response has given the ratio of lignin to cellulose.

Question 4(a)ii

This question asked candidates to give one conclusion that can be made about the effect of age on the mean percentage of both cellulose and lignin content of bamboo plants.

Candidates who read the question carefully were able to analyse the graph to give a correct conclusion.

Some candidates did not refer to age in their conclusions whereas some only referred to one of the molecules.

- (ii) Give **one** conclusion that can be made about the effect of age on the mean percentage of **both cellulose and lignin** content of bamboo plants.

(1)

By increasing age in lignin mean percentage increases, cellulose decreases



A correct conclusion scored one mark.

- (ii) Give **one** conclusion that can be made about the effect of age on the mean percentage of **both cellulose and lignin** content of bamboo plants.

(1)

There is no effect of age on cellulose and lignin percentage ^{content} of bamboo plants.



This is an incorrect conclusion.

Question 4(a)iii

This question asked candidates to explain how the arrangement of molecules in the cell walls of xylem contributes to the high tensile strength of the bamboo plant.

It was important that candidates read the question carefully to understand that they were asked to explain the arrangement of more than one molecule in the cell wall.

Some candidates only explained the arrangement of cellulose molecules, which limited the number of marks they could achieve. There was some confusion about where the hydrogen bonds were being formed, with a significant number of responses referring to them being formed within a cellulose molecule instead of between adjacent molecules.

Most candidates showed a good knowledge of the arrangement of cellulose molecules in the cell walls of xylem, which would contribute to a high tensile strength.

Higher quality answers gained maximum marks for descriptions of hydrogen bonding between cellulose molecules or microfibrils, their arrangement in layers or mesh, and a description of lignin in secondary thickening.

A few candidates described microfibrils embedded in hemicellulose or pectin.

- (iii) Explain how the arrangement of molecules in the cell walls of xylem contributes to the high tensile strength of the bamboo plant.

(3)

Cellulose are made from β -glucose inverted 180° to each other forming long molecules. Hydrogen bonds form between cellulose molecule aligned parallel to each other forming microfibrils. Microfibrils tangles further forming macrofibrils, which in order arrange itself into cellulose fibres. Those fibres mesh creating a cross like pattern forming cellulose in cell walls. Both hydrogen bonds between structures and rope-like arrangement increase tensile strength.



This response explained the arrangement of only cellulose molecules in the cell wall so was not able to access full marks. Marking points one and two were awarded.



Read the question carefully to understand what you need to do.

- (iii) Explain how the arrangement of molecules in the cell walls of xylem contributes to the high tensile strength of the bamboo plant.

(3)

There are hydrogen bonds between adjacent cellulose molecules and forming microfibrils that are arranged in layers at different angles forming a mesh. ~~Lignin is deposited~~ Lignin is deposited as a helical and spiral shape ~~with~~ increasing the strength ~~and the~~ of the cell wall, increasing cell stability. Calcium pectate also forms the middle lamella that holds adjoining cells together in a matrix of hemicelluloses. Secondary thickening reduces the flexibility of the cell wall.



This response scored three marks, for marking points one, two and four.

(iii) Explain how the arrangement of molecules in the cell walls of xylem contributes to the high tensile strength of the bamboo plant.

(3)

• Cellulose is stored in ~~many~~ many microfibrils.
• These microfibrils are ~~set~~ in a mesh like pattern.
↓
arranged.

• This forms a cell wall which is waterproof.



This response scored marking point two only.

Question 4(c)ii

This question asked candidates to give one difference between the arrangement of xylem and phloem in the stem compared to the arrangement in the provided leaf diagram.

It is important to read the question carefully as well as analyse the information provided.

Some candidates described the arrangement of the two structures in the leaf, but did not compare with the arrangement in the stem. Some answers contradicted themselves, which prevented the awarding of marks.

Some candidates described the structure or the function of xylem and phloem, which was not creditworthy. Some candidates described how the proportion of xylem to phloem changed and this did not answer the question.

Where candidates did read the question carefully, they usually demonstrated their knowledge of this aspect of the specification in a clear comparative answer.

- (ii) Give **one** difference between the distribution of phloem and xylem in the leaf compared with their distribution in a transverse section of a stem.

xylem and phloem bundles
The ~~xylem~~ would form a circle inside stems, with
xylem on the closer to the middle. (1)



(Total for Question 4 = 8 marks)



This response gained the mark for describing, and showing in their labelled diagram, the different distribution of phloem and xylem in a stem compared to the leaf diagram above.



A clear labelled diagram can be beneficial to your answer. However a diagram without labels will not be helpful.

- (ii) Give **one** difference between the distribution of phloem and xylem in the leaf compared with their distribution in a transverse section of a stem.

xylem faces the upper surface of the leaf while
Phloem faces the lower surface of the leaf

(Total for Question 4 = 8 marks)



This response scored 0 marks as they have not given a difference between the distribution in a stem compared to the provided leaf diagram.

- (ii) Give **one** difference between the distribution of phloem and xylem in the leaf compared with their distribution in a transverse section of a stem.

The distribution of phloem and xylem in the leaf is to transport
the organic compounds away from it, while that in the stem is
to transport the organic compounds to all the plants to provide
energy.

(Total for Question 4 = 8 marks)



This response scored 0 as the candidate did not give a difference in the arrangement of the phloem and xylem.

- (ii) Give **one** difference between the distribution of phloem and xylem in the leaf compared with their distribution in a transverse section of a stem.

(1)

in the leaf there are more xylem

(Total for Question 4 = 8 marks)



This is not a difference in the distribution of phloem and xylem.

Question 5(a)

This question was centred around the context of a cup made from waste products from the commercial production of sugar.

Candidates were asked to explain why this cup would be considered to be a sustainable product.

Generic responses which were not applied to the specific context of 'this' cup could not gain full marks.

5 Many useful products can be made from plants.

(a) The photograph shows a drinking cup.



(Source: © Alex Hinds / Alamy Stock Photo)

This cup is made from parts of a sugarcane plant that are left over from commercial production of sugar.

Explain why **this** cup would be considered a sustainable product.

(2)

Because it is made from something that will never run out and that could always be made more ~~of~~ if necessary. Also you don't contaminate nor destroy the ecosystem when you produce it.



This response is vague and does not directly link to the given context. The candidate needed to refer to sugar/sugar cane/plant or waste from sugar production for mp1. 0 marks were awarded.

5 Many useful products can be made from plants.

(a) The photograph shows a drinking cup.



(Source: © Alex Hinds / Alamy Stock Photo)

This cup is made from parts of a sugarcane plant that are left over from commercial production of sugar.

Explain why **this** cup would be considered a sustainable product.

(2)

it is renewable source doesn't run out
as sugarcane can be regrown in future
generations and it is biodegradable
and can be decomposed and it is carbon
~~neutral~~ neutral



This response gained both marking points.

5 Many useful products can be made from plants.

(a) The photograph shows a drinking cup.



(Source: © Alex Hinds / Alamy Stock Photo)

This cup is made from parts of a sugarcane plant that are left over from commercial production of sugar.

Explain why **this** cup would be considered a sustainable product.

(2)

If u made from renewable products
It is biodegradable
It is carbon neutral.



This response did not gain marking point one as there was no direct link to the given context. They gained marking point two for either line two or three.

Question 5(b)

This question provided candidates with information about an investigation into the antimicrobial properties of olive oil extracts.

Candidates needed to read the given information and analyse the graph carefully.

Candidates also needed to take careful note of the command word 'comment on'. This command word requires the synthesis of a number of factors to form a judgement.

Most candidates could make a judgment that the olive oil extracts had antimicrobial properties as they decreased the number of living bacteria. However, a number of candidates spent a lot of their response describing the graph without consideration of any other aspect in their response.

Many candidates could form the judgement that the higher concentration was more effective/had more antimicrobial properties.

Many candidates commented on error bars, but they need to clearly state what overlapping/non-overlapping error bars signify as well as be specific as to which overlap/do not overlap. Many candidates did not gain marking point three because they stated that no error bars were overlapping, which is incorrect.

Those candidates who read the given information carefully often gained marking point four for a relevant comment regarding variables that had been controlled or for commenting on there was no information for a specific variable that should have been controlled for a valid judgement to be made.

Comment on the results of this investigation.

(4)

On Zero Time none of the extracts had an effect on the bacteria.

Both the concentrations of extract decrease the mean number of living bacteria.

Between 0 and 0.5 hours the extract with high concentration has the highest decrease in mean number of living bacteria, and by the 5 hour mark all bacteria was killed with high concentration extract. By hour 7 all bacteria was dead by both concentrations. So as concentration increase the rate of killing bacteria increase.



This response gained the first marking point for their second paragraph. There was no other creditworthy judgment or comment in this response.



Descriptions of the graph are unlikely to gain many marks in a 'comment on' question.

Comment on the results of this investigation.

(4)

At the start (0 hours) they all have the same number of living bacteria which increases validity. No change occurs ~~at~~ in the mean number of bacteria in the control solution at all times, as time increases ~~both~~ the number of living bacteria in both ~~the~~ low and high ~~concentration~~ concentration of extract decreases as the extract contains antimicrobial properties. The high ~~at~~ concentration of extract is the most effective as it takes the least time to kill all the bacteria because it has the most antimicrobial properties. Error bars don't overlap ~~so the~~ difference is significant from 0.5 to 7 hours. Doesn't ~~control~~ control other factors ~~eg~~ e.g. the temperature and humidity of each solution.



This is an example of a detailed response which gained four marks, mp4,1,2,3. They have been specific in stating which error bars do not overlap and the significance of this.



Generic statements regarding error bars are unlikely to gain credit.

Comment on the results of this investigation.

(4)

high ~~are~~ both concentrations of extract ^{with time} cause a decrease in living bacteria. But a higher concentration is more effective as it shows no more bacteria found. No overlap of error bars so give significant difference in concentrations of bacteria, mean is calculated so more reliable. No idea about other controlled variables that may effect bacteria such as temperature. Control to compare results more valid. as



This response gained marking points 1, 2 and 4. They have incorrectly stated that there was no overlap of error bars.

Question 5(c)i

This question required candidates to analyse the given graph in order to state the relationship between the time in interphase and the number of cells.

Most candidates could analyse the graph correctly and gave a correct relationship. However, the two lines and two y axis scales caused difficulties for some students.

A small minority of students did not refer to both time in interphase and number of cells in their answer. Relationships between concentration of PHA and either time in interphase or number of cells were not creditworthy.

(i) State the relationship between the time in interphase and the number of cells.

(1)

As number of cells increases, time in interphase decreases. Inversely proportional



A correct answer which scored one mark.

(i) State the relationship between the time in interphase and the number of cells.

(1)

As the time in interphase increases the number of cell increases and the time in interphase decreases



This response included a contradiction so no mark was awarded.

Question 5(c)iii

This question asked candidates to explain the results of the investigation of the effect of PHA concentration on two aspects relating to white blood cells.

Most candidates described the link between increasing PHA concentration and either increased number of cells or decrease in time spent in interphase.

Many candidates extended their answer to include the effect on mitosis or cell division.

Some candidates recognized that DNA and organelles are replicated in interphase but did not make the link that these processes must happen faster if interphase is shortened.

Some higher-level responses related this to an increase in the mitotic index.

(iii) Explain the results of this investigation.

(3)

As the concentration of PHA increases, the time in interphase decreases, so faster interphase, so faster DNA replication, faster organelle replication, so faster cell cycle, so the cells divide in a period of time than normal, so more cells are produced, so number of cells increases.

(Total for Question 5 = 11 marks)



This response scored two marks, marking points one and two. They have given an explanation as to why the time in interphase decreased.

(iii) Explain the results of this investigation.

(3)

As the concentration of PMA increased, the time in interphase of cell decreased, stage G₁, S, and G₂ were happening rapidly, this lead to increased numbers of cells till 160 hours. A concentration of PMA of about $0.3 \mu\text{g cm}^{-3}$ made ~~se~~ rapid and quick changes. From concentrations 0.6 to $1 \mu\text{g cm}^{-3}$ the effect was same as the interphase was happening at its maximum robust limit.

(Total for Question 5 = 11 marks)



This is an example of a response which only scored marking point one. Although they know some aspects of interphase have occurred quicker, this was the additional guidance for marking point one.

(iii) Explain the results of this investigation.

(3)

As time in interphase decreased, number of cells increased. This is because mitotic rate increased so ~~mitotic~~ & mitotic index increased.

$2 \mu\text{g cm}^{-3}$ is the optimum concentration for the ~~lower~~^{higher} time in interphase.

(Total for Question 5 = 11 marks)



This is an example of a response which included the effect on the mitotic index in their explanation.

Question 6(a)i

This question asked candidates to suggest how cell damage could lead to the activation of the sox2 gene.

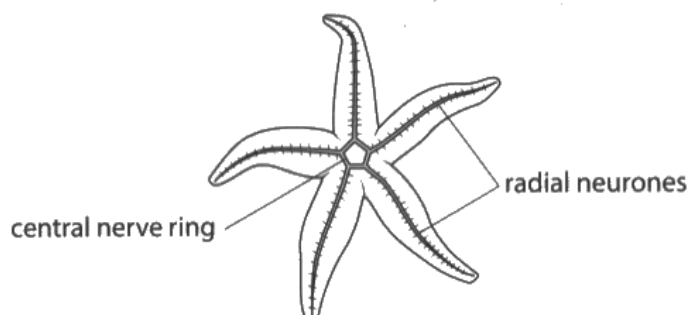
Many candidates recognized that epigenetic modifications/differential gene expression would be involved, but did not include how this would lead to more transcription, limiting the number of marks they could access.

Higher-level responses included details of the epigenetic modification and how it could allow the binding of RNA polymerase to the promoter region of sox2 gene.

A minority of candidates suggested cell specialization or nervous stimulation which were not creditworthy.

6 Multicellular organisms, like starfish, contain many different types of cells.

(a) The diagram shows part of the nervous system of a starfish.



(Source: adapted from <https://royalsocietypublishing.org/doi/pdf/10.1098/rstb.1950.0010>)

(i) When nerve cells are damaged in this starfish, the gene *sox2* is activated. Suggest how cell damage could lead to activation of this gene.

(2)

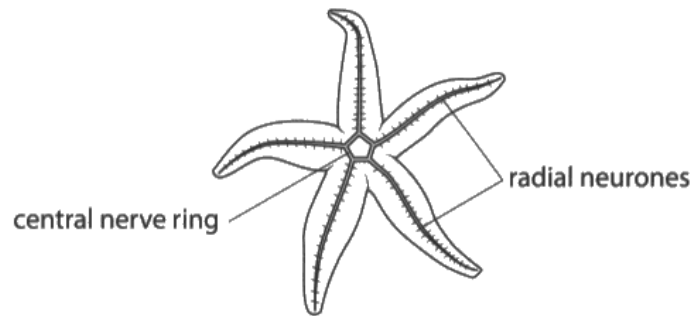
when cell is damaged the sensory organ sends nerve impulse to the sensory neuron, and sensory neuron to the relay neuron, then to the central nerve ring which activate the gene *sox2* then ~~then~~



Answers relating to impulses stimulating activation of the gene were not credited.

6 Multicellular organisms, like starfish, contain many different types of cells.

(a) The diagram shows part of the nervous system of a starfish.



(Source: adapted from <https://royalsocietypublishing.org/doi/pdf/10.1098/rstb.1950.0010>)

- (i) When nerve cells are damaged in this starfish, the gene *sox2* is activated. Suggest how cell damage could lead to activation of this gene.

(2)

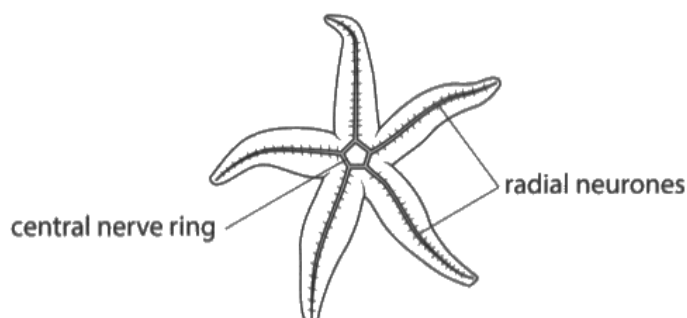
might trigger demethylation ^{or} ~~acetylation~~ acetylation of the
gene, ~~then~~ ~~the~~ turning this gene on and mRNA produced
because ~~RNA~~ ~~transcription~~ transcription factors can bind



This response was awarded marking points one and four. DNA acetylation is incorrect.

6 Multicellular organisms, like starfish, contain many different types of cells.

(a) The diagram shows part of the nervous system of a starfish.



(Source: adapted from <https://royalsocietypublishing.org/doi/pdf/10.1098/rstb.1950.0010>)

(i) When nerve cells are damaged in this starfish, the gene *sox2* is activated.
Suggest how cell damage could lead to activation of this gene.

(2)

The starfish ~~any~~ leg may be cut so radial neurones leading to the central nerve ring are cut, damaged so DNA demethylation, or epigenetic modification, occurs that switches on the gene.



This response gained marking point one for either DNA demethylation or epigenetic modification, but did not go on to give the detail of how this would result in gene activation.

Question 6(a)ii

This question asked candidates to give one difference between a pluripotent and a totipotent stem cell.

Many candidates did not fully understand the differences between these two stem cell types or used low level language in their answer. Some candidates confused embryonic cells and extra-embryonic cells.

- (ii) Activation of the sox2 gene can stimulate body cells to become pluripotent stem cells.

Give **one** difference between a **pluripotent** stem cell and a **totipotent** stem cell.

(1)

Plus Totipotent stem cell can form placenta and umbilical cord while pluripotent Totipotent stem cell can differentiate into any type of cell while Pluripotent stem cell can only differentiate into some type of body cell excluding extra embryonic tissue



An example of a correct response which was awarded one mark.

- (ii) Activation of the *sox2* gene can stimulate body cells to become pluripotent stem cells.

Give **one** difference between a **pluripotent** stem cell and a **totipotent** stem cell.

(1)

totipotent cells differentiate into
embryonic cells, pluripotent do not



This is an example where the candidate has confused embryonic cells with extra-embryonic cells.

- (ii) Activation of the *sox2* gene can stimulate body cells to become pluripotent stem cells.

Give **one** difference between a **pluripotent** stem cell and a **totipotent** stem cell.

(1)

→ Totipotent stem cell can give all type of cells
while the Pluripotent stem cell gives most type of cells
except the extra embryonic tissues.



This response used low level language in their answer and did not gain the mark. Candidates should have referred to differentiation or specialisation of cells.



Think about the key terminology you should use in your answers.

Question 6(b)

This question provided candidates with a diagram showing that post-transcriptional changes to a strand of pre-mRNA resulted in three different strands of active mRNA.

Candidates were asked to explain how these three active mRNA stands are produced.

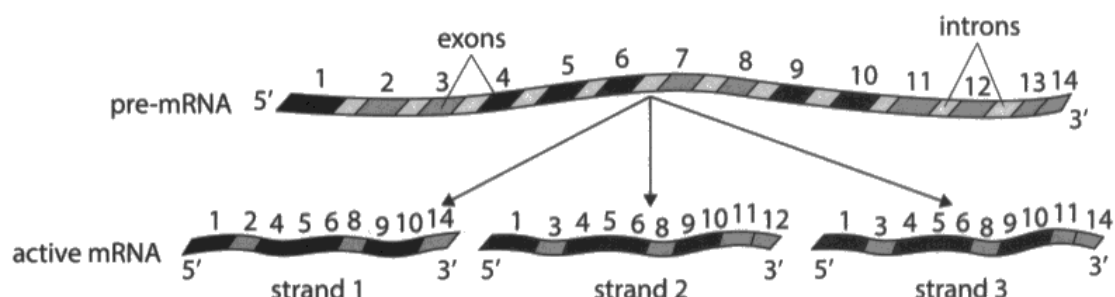
This proved to be a challenging question for some candidates and a very good differentiator.

Most students knew that introns and some exons were removed from pre-mRNA by spliceosomes. However, many candidates tried to give a generic answer from previous mark schemes instead of applying their knowledge to the given diagram. As a result, they could not gain full marks. Statements that some exons were rearranged were incorrect for this context.

The higher-level responses accessed the AO2 aspect of the question and correctly identified similarities and differences in exon removal for each of the three strands.

(b) One gene from this starfish pluripotent stem cell produces pre-mRNA.

The diagram shows how three different strands of active mRNA are produced from one strand of pre-mRNA.



Explain how **these** three active mRNA strands are produced.

Use the diagram to support your answer.

(4)

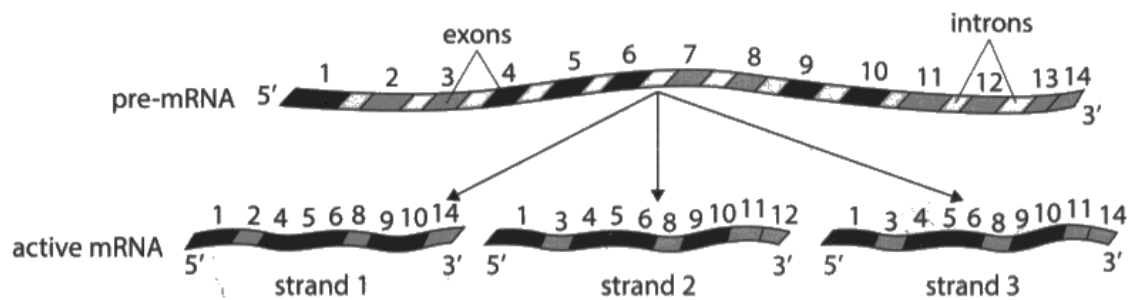
Active mRNA is produced from pre-mRNA which has both exons and introns (non coding bases) present. Spliceosomes are a ligase which splice the pre-mRNA to remove the non-coding introns in order to join the exons and form active mRNA. The diagram displays the active mRNA is joined to 3 strands without the introns which are present in pre-mRNA. ~~Act~~ Pre-mRNA is spliced and introns are removed to ~~produce~~ join active mRNA with exons (coding).



This response gained marking point two only.

(b) One gene from this starfish pluripotent stem cell produces pre-mRNA.

The diagram shows how three different strands of active mRNA are produced from one strand of pre-mRNA.



Explain how **these** three active mRNA strands are produced.

Use the diagram to support your answer.

(4)

By RNA splicing
The introns which are the non-coding parts
are removed by splicosomes
The exons are rearranged by enzyme
The exons are then ~~joined~~ joined together by
complementary base pairing mechanism using
splicosomes



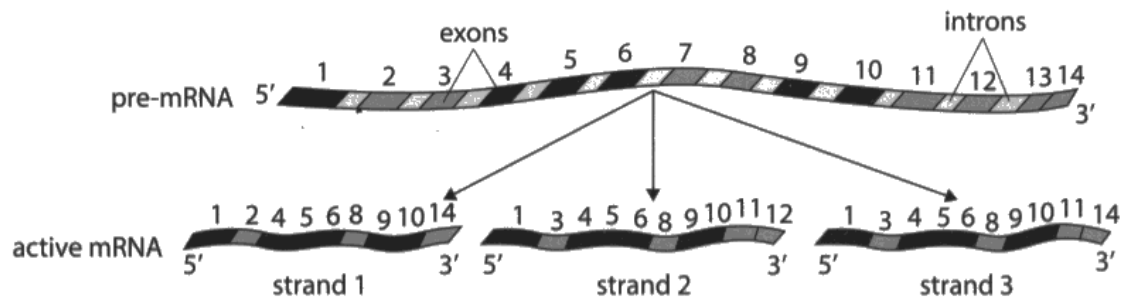
This response incorrectly stated that the exons were rearranged, which is not what the diagram shows.



Do not repeat statements from previous mark schemes that are not relevant to the new context.

(b) One gene from this starfish pluripotent stem cell produces pre-mRNA.

The diagram shows how three different strands of active mRNA are produced from one strand of pre-mRNA.



Explain how **these** three active mRNA strands are produced.

Use the diagram to support your answer.

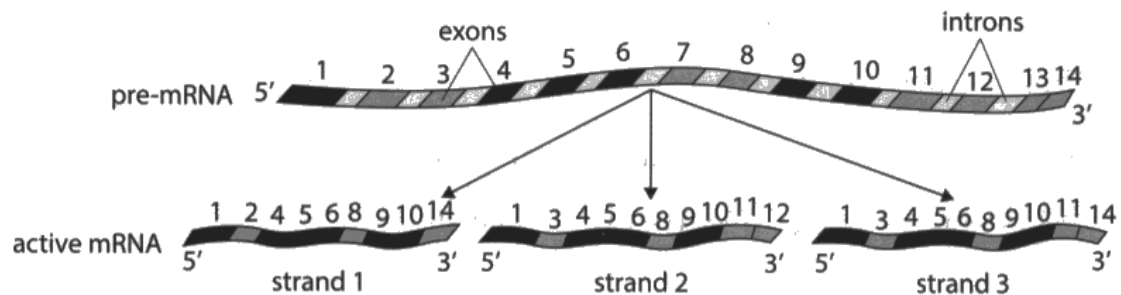
(4)
All introns are removed and some exons were removed by the enzyme called the spliceosome. The exons were joined differently to form active mRNAs by the spliceosome as well. The exons were joined different to form different codes of the active mRNA which code for different genes.



This is an example of the most commonly awarded marking points, two and three. The candidate has correctly explained that introns and some exons are removed by spliceosomes. Although they have recognised that the exons were joined differently, they have not used the diagram to support a deeper explanation.

(b) One gene from this starfish pluripotent stem cell produces pre-mRNA.

The diagram shows how three different strands of active mRNA are produced from one strand of pre-mRNA.



Explain how **these** three active mRNA strands are produced.

Use the diagram to support your answer.

(4)

During transcription ^{whole} the gene with all introns and exons is transcribed producing pre-mRNA. By post transcription modification, introns are removed by enzymes (spliceosomes) and exons are rearranged and some may be removed forming ^{different} active mRNA like in strand 1 exons 3, 7, 11 and 12, 13 are removed, and in strand 2 exons 2, 7, 14 these ~~different~~ are removed and in strand 3 exons 2, 7, 12 and 13 are removed, each different mRNA code for different sequence of amino acids on the ^{active} polypeptide chain.



This response gives a clear explanation of post-transcriptional changes to the given pre-mRNA strand in the diagram and how the three different active mRNA strands were produced. Marking points 1,2,3 and 4 were awarded.



Always apply your knowledge to the given context.

Question 6(c)

Candidates were asked to suggest why society has approved the use of stem cells taken from starfish for research.

Candidates are reminded to use the number of marks as a guide as to how many suggestions they should make.

Most candidates gained marking point three, either for a consideration of the ethical issues or the suggestion that society would prefer to use an alternative to stem cells taken from human embryos.

Many candidates also considered that stem cells could differentiate into different types of cells.

However fewer candidates could give creditable suggestions as to the type of research that society would approve the use of these stem cells, with a significant number repeating research unqualified from the stem of the question.

(c) Society has approved the use of stem cells taken from starfish for research.

Suggest why society has approved the use of these **stem cells**.

(3)

- not taken from humans or IVF embryonic cells so it is not ethical wrong and it doesn't kill embryos
 - these stem cells can help for medical research and new findings in curing people and saving lives.
 - it is not painful
 - stem cells don't need to be re-taken and repeated the process as it is long term when stem cells are used
- (Total for Question 6 = 10 marks)



This response gained marking points two and three.

(c) Society has approved the use of stem cells taken from starfish for research.

Suggest why society has approved the use of these **stem cells**.

(3)

Because cures for disease can be discovered since the pluripotent stem cells can differentiate to most types of cells and can make tissues and organs to be transplanted to sick patients and can save lives. Human lives can be considered more important than starfish so there are less - no ethical issues. Starfish might not have to be killed for research and society accepts this as the people want to be healthy and not have diseases.

(Total for Question 6 = 10 marks)



This is an example of a response which scored all three marking points, their suggestion that the use was approved so human lives could be saved due to advances in organ transplant research was creditworthy.

(c) Society has approved the use of stem cells taken from starfish for research.

Suggest why society has approved the use of these **stem cells**.

(3)

Not considered unethical because star fish is not killed by gathering stem cells, star fish can regrow the damaged cells, star fish are

(Total for Question 6 = 10 marks)



This response gained marking point three only.

Question 7(a)i

This question was centred around the hydroponic system in the photograph.

Candidates were asked to give two reasons why water is important to the strawberry plants.

Most candidates knew the importance of water in hydrolysis/metabolic reactions and photosynthesis was a commonly named example.

Many candidates knew that water was a solvent or was involved in transport, but did not give the level of detail required as to what solutes would be dissolved/transported that would be important to the strawberry plants. Candidates should be encouraged to be more specific and detailed in their answers.

- 7 The photograph shows strawberry plants growing in a hydroponic system.
In these systems, the plants grow in nutrient solutions instead of in soil.



(Source: © Stephanie Jackson - Agriculture / Alamy Stock Photo)

The nutrient solutions contain inorganic ions and water.

- (a) (i) Give **two** reasons why water is important to the strawberry plants.

(2)

- 1 Water is used as reactants in photosynthesis.
- 2 Water is used for hydrolysis reaction -



This response gained marking point one only.

7 The photograph shows strawberry plants growing in a hydroponic system.

In these systems, the plants grow in nutrient solutions instead of in soil.



(Source: © Stephanie Jackson - Agriculture / Alamy Stock Photo)

The nutrient solutions contain inorganic ions and water.

(a) (i) Give **two** reasons why water is important to the strawberry plants.

(2)

- 1 Water is a reactant in photosynthesis that can combine with CO_2 to form glucose needed for energy for plant and other consumers.
- 2 Water acts as a solvent for transportation of mineral ions in xylem and translocation of sucrose in the phloem.



This response gained marking points one and two.

Question 7(a)ii

This question asked candidates to explain the importance of nitrate ions and calcium ions to the strawberry plants.

It is important that candidates read the question carefully. A significant number of responses explained the importance of magnesium ions, which was not creditworthy.

Most candidates could explain that nitrate ions were needed to make a correctly named molecule, with all the molecules in the marking point seen. Fewer candidates could extend their

answers to explain why these molecules were needed by the strawberry plants.

Similarly, many candidates could state that calcium ions were needed to form calcium pectate, with fewer candidates explaining why this would be beneficial to the strawberry plants.

(ii) The nutrient solution contains nitrate ions and calcium ions.

Explain the importance of these ions to the strawberry plants.

(3)

Calcium ions are needed for producing calcium pectate, which ~~is~~^{is} ~~is~~ used in the middle lamella of plants to stick adjacent plant cells together. This helps with support and structure of the plant cells. Nitrate ions are important in the making of amino acids and nucleotides of the DNA, which are used in the synthesis of proteins and enzymes needed for metabolic reactions like photosynthesis and growth of the strawberry plant.



This response gives a good explanation of the importance of these two inorganic ions to the plants and scored full marks.

Question 7(c)i

This question required candidates to extract the relevant data from the provided table and substitute it into the provided equation.

Most candidates used the correct data, but a number of candidates used the gluten data. Candidates are encouraged to check the provided information carefully.

Most candidates could substitute the data correctly into the equation, but some made errors in the add or subtract symbols.

A significant number of candidates calculated the denominator incorrectly due to errors handling the brackets.

Candidates are reminded of the importance of checking back after performing the calculation to see how their answer should be presented. Answers to a lower number of decimal places than the provided data were not awarded full marks.

- (i) Calculate the percentage difference in the mean mass of wheat grains of the plants in group A and group B.

Use the equation:

$$\text{percentage difference between A and B} = \frac{A - B}{\left(\frac{A + B}{2} \right)} \times 100$$

Give your answer to an **appropriate number of decimal places**.

(2)

Answer 28 %



An incorrect answer with no working scored 0 marks.

- (i) Calculate the percentage difference in the mean mass of wheat grains of the plants in group A and group B.

Use the equation:

$$\text{percentage difference between A and B} = \frac{A - B}{\left(\frac{A + B}{2}\right)} \times 100$$

Give your answer to **an appropriate number of decimal places.**

(2)

$$\frac{0.58 - 0.65}{\left(\frac{0.58 + 0.65}{2}\right)} \times 100$$

Answer 11.4 %

$$= - \frac{0.07}{0.615} = -0.11382 \times 100 = -11.382$$



This is an example of a correctly calculated answer which was not given to an appropriate number of decimal places. The response was awarded one mark.

- (i) Calculate the percentage difference in the mean mass of wheat grains of the plants in group A and group B.

Use the equation:

$$\text{percentage difference between A and B} = \frac{A - B}{\left(\frac{A + B}{2}\right)} \times 100$$

Give your answer to **an appropriate number of** decimal places.

(2)

$$\frac{0.58 - 0.63}{\frac{0.58 + 0.63}{2}} \times 100 = -11.382113\ldots$$

Answer - 11.38 %



An example of a correctly calculated answer given to an appropriate number of decimal places.



Look at how the raw data is presented.

Question 7(c)ii

This was the first level-based question on the paper.

Candidates were given information regarding an investigation into the effect of magnesium ions on the mean mass of wheat grains and the mean gluten content of wheat grains. They were also provided with information about the involvement of magnesium ions with enzyme activation and more expensive four protein content.

Candidates were provided with a conclusion from a farmer that they would make more money if magnesium ions were added to growing plants. They were asked to discuss this conclusion.

The most common way that candidates achieved level one was by giving a correct conclusion from the table data and concluding that the farmer would have a higher yield with higher {protein/gluten} content.

The most common way that candidates achieved level two was by linking correct biological knowledge to some of the enzyme actions given in the question, for example discussing the effect on plants of increased photosynthesis and protein synthesis. They also considered other relevant costs to the farmers or considered the validity of the investigation.

The most common way that candidates achieved level three was by giving a detailed discussion of evidence for and against the conclusion, often linking correct biological knowledge to all enzyme actions given in the question, for example discussing the effect on plants of increased uptake named inorganic ions by active transport, as well as linking glucose to ATP production. They considered other relevant costs to the farmers and considered the validity of the investigation.

- * (ii) Farmers concluded that they would make more money if magnesium ions were added to growing wheat plants.

Discuss this conclusion.

Use **all** the information in part (c) to support your answer.

(6)

Adding all inorganic ions except magnesium ions ~~cause~~ provide ^{more} less mass of wheat grains and less mass of gluten in wheat grains, but when adding all inorganic ions including magnesium ion in group C ~~it~~ magnesium ion solution doesn't reach the ~~leaf~~ leaves but it gives highest mass of wheat grains and highest mass of gluten. The difference between adding and not adding magnesium ion is big, as the difference between group A and B is 0.114%.



Descriptions of the data were limited to a lower level one response.

- *(ii) Farmers concluded that they would make more money if magnesium ions were added to growing wheat plants.

Discuss this conclusion.

Use **all** the information in part (c) to support your answer.

~~A~~ group A has lowest yield, where no Mg^{2+} applied at all. ⁽⁶⁾

group C has highest yield with Mg^{2+} ~~applied~~ solution applied.

group B has higher yield than A, because Mg^{2+} applied to leaves.

Mg^{2+} can be absorbed by plants most efficiently by applied in solution.

As ~~more~~ Mg^{2+} applied, gluten mass in grains increase.

Mg^{2+} ~~has~~ are used in synthesis of chlorophyll, used in photosynthesis, used to convert light energy into biomass.

more chlorophyll, higher wheat yield, more profit and thus more money for farmers.

~~No~~

(Total for Question 7 = 14 marks)



This is an example of a lower level two response. They have made a limited attempt to link biological knowledge to the given context to support their conclusion that the farmer was right to think they would make more money.

- *(ii) Farmers concluded that they would make more money if magnesium ions were added to growing wheat plants.

Discuss this conclusion.

Use **all** the information in part (c) to support your answer.

(6)

When magnesium ions are added to growing wheat plants the active site of the inactivated enzyme changes shape so substrates can now bind to the active site and enzymes become activated. Substrates can bind so enzyme-substrate complexes can be formed lowering the activation energy of photosynthesis, protein synthesis and active transport of mineral ions. When magnesium is added the rate of protein synthesis increases so more gluten is produced by wheat plants so flour made by their grains will have high protein content so it will be more expensive increasing the profit revenue, profit, of the farmers. However, magnesium ion solution may be expensive to buy increasing production costs of farmers. Magnesium ions increase the rate of photosynthesis so more glucose is produced by wheat plants so more respiration takes place increasing the growth of wheat plants so more grains are produced so more flour can be made. More grinding of grains into flour may increase production costs thus decreasing profit. Magnesium ions also increase uptake of mineral ions by active transport so more calcium ions are taken up which form the middle lamella that increases the strength of cell walls, more nitrate ions to form DNA and ATP which can be used in active transport and mitosis, and also more magnesium ions that form chlorophyll which converts light energy into chemical energy in photosynthesis. The mean mass of wheat grains is the highest and the mean mass of gluten in grains is the highest in the solution with magnesium ions. When magnesium ion solution is added to leaves there is a greater mass of grains and greater mass of gluten in grains.

(Total for Question 7 = 14 marks)



This is an example of a level three response. They have given a detailed discussion of evidence for and against the conclusion and applied their biological knowledge to the provided information, for example discussing the effect on plants of increased protein synthesis and photosynthesis, increased uptake of several other named inorganic ions by active transport, as well as linking ATP to active transport of named inorganic ions. They considered other relevant costs to the farmers too.

Question 8(a)

Candidates were told that the acrosome reaction is stimulated when a sperm cell binds to the ZP3 protein on the zona pellucida of an egg cell.

They were then asked to describe the acrosome reaction.

Most candidates knew some aspects of the acrosome reaction, but the lack of correct biological terminology often prevented the awarding of marks.

Many candidates wasted time and answer space repeating the given information regarding binding to the ZP3 protein.

Few candidates referred to the fusing of the acrosome with the cell surface membrane.

Most candidates knew that acrosin/digestive enzymes would be released which would digest the zona pellucida; however some candidates used inappropriate terminology such as 'eating' or enzymes unqualified.

Higher level responses included the fusion of the two cell membranes.

8 An egg cell is a specialised cell.

- (a) The acrosome reaction is stimulated when a sperm cell binds to the ZP3 protein on the zona pellucida of an egg cell.

Describe the acrosome reaction.

(3)

The acrosome reaction will cause the sperm cell to enter the egg cell and fertilise and the sperm cell's nucleus gets binded with the egg cell's nucleus



This response did not describe the acrosome reaction and scored 0 marks.

8 An egg cell is a specialised cell.

- (a) The acrosome reaction is stimulated when a sperm cell binds to the ZP3 protein on the zona pellucida of an egg cell.

Describe the acrosome reaction.

(3)

When the sperm cell comes to contact with the zona pellucida, the hydrolytic enzymes of the acrosome at the tip of the sperm cell are released. The enzymes digest the zona pellucida, ^{and eventually} allowing the haploid nucleus from sperm to enter the egg cell to let fertilisation occur.



This is an example of a response which gained the most commonly awarded marking points, two and three.

8 An egg cell is a specialised cell.

- (a) The acrosome reaction is stimulated when a sperm cell binds to the ZP3 protein on the zona pellucida of an egg cell.

Describe the acrosome reaction.

(3)

~~As the cell membrane of sperm binds to the sperm receptor protein on egg.~~
Acrosine enzyme is released which breaks down the zona pellucida allowing sperm cell to reach to the cell membrane of ovum, the 2 cell membrane ~~are~~ fuses and the haploid sperm nucleus enters the egg cell.



This response gained three marks as marking points two, three and four were awarded.

8 An egg cell is a specialised cell.

- (a) The acrosome reaction is stimulated when a sperm cell binds to the ZP3 protein on the zona pellucida of an egg cell.

Describe the acrosome reaction.

(3)

acrosome membrane fuses with the sperm head membrane and enzyme acrosin is released by exocytosis ~~the~~ where enzyme acrosin digests the zona pellucida and make a pathway for sperm head to reach the egg cell membrane ~~the~~ then fusion of both sperm head membrane and egg cell membrane occurs and male ~~nucleus~~ nucleus enters the ~~an~~ egg cell for fertilization



This response covered all four marking points to gain full marks.

Question 8(b)i

Candidates were told that when a sperm cell arrives at an egg cell surface it binds to a receptor on the egg cell surface membrane. They were also provided with a diagram showing the sperm receptor on the egg cell surface and a complementary shaped egg-binding protein on the sperm cell.

Candidates were also expected to analyse the given diagram carefully to note these aspects and also recognise that if the zona pellucida was intact then it would have covered the sperm receptor.

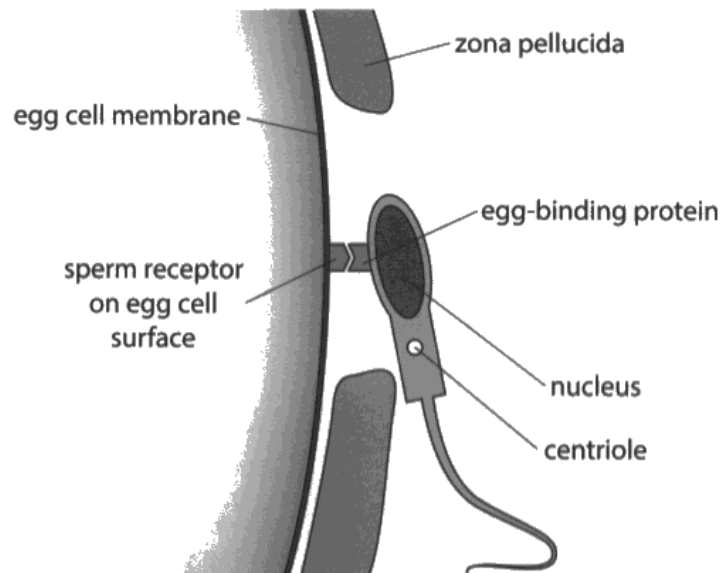
Candidates were asked to suggest why some sperm cells may not be able to bind to the sperm receptor on the egg cell surface membrane. This question proved challenging for many candidates.

Many candidates were able to suggest reasons relating to marking point one, for example sperm receptor and binding protein were no longer complementary, were missing or the receptor was already occupied. Some responses were seen suggesting named deformities of the sperm cell.

Some candidates extended these points by suggesting that mutation may be the cause of the change in protein shape. Some gained marking point two for varying credit worthy suggestions relating to the zona pellucida.

- (b) When a sperm cell arrives at an egg cell surface it binds to a receptor on the egg cell surface membrane.

The diagram shows a sperm cell binding to a complementary shaped receptor on the egg cell surface membrane.



(Source: adapted from <https://www.sciencedirect.com/topics/nursing-and-health-professions/zona-pellucida-glycoprotein>)

- (i) Suggest why some sperm cells may not be able to bind to the sperm receptor on the egg cell surface membrane.

(3)

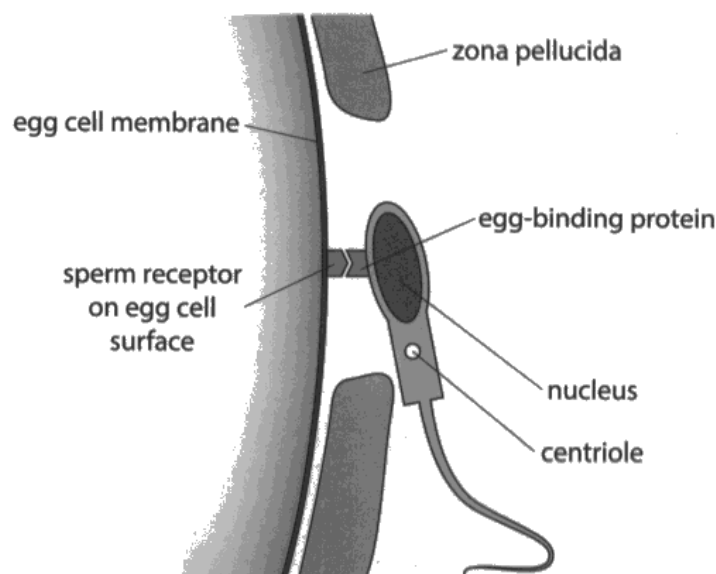
Because they may lack the egg-binding protein that binds on the sperm receptor.



One suitable suggestion which enabled marking point one to be awarded.

- (b) When a sperm cell arrives at an egg cell surface it binds to a receptor on the egg cell surface membrane.

The diagram shows a sperm cell binding to a complementary shaped receptor on the egg cell surface membrane.



(Source: adapted from <https://www.sciencedirect.com/topics/nursing-and-health-professions/zona-pellucida-glycoprotein>)

- (i) Suggest why some sperm cells may not be able to bind to the sperm receptor on the egg cell surface membrane.

(3)

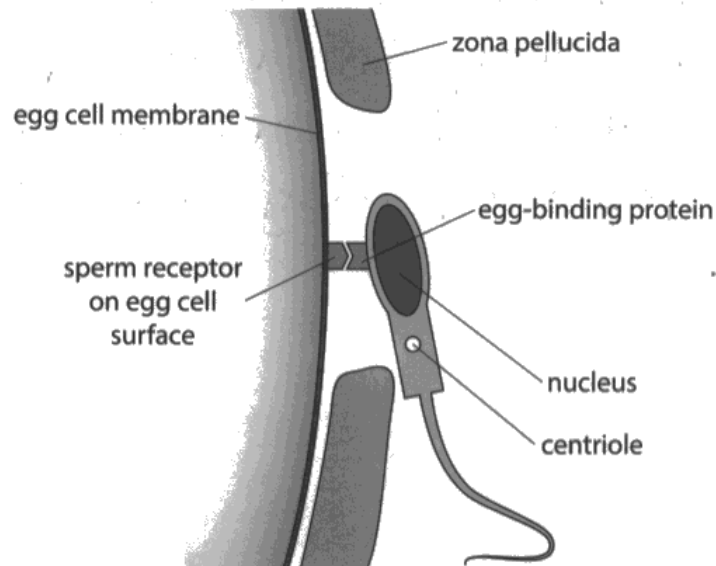
binding site
Sperm cells¹ may not have the same shape as the receptors.
Or the receptor might be occupied. Some sperm cells
cannot reach the egg membrane due to energy or flagellum
Also sperm cell may not enter since zona pellucida may
harden because of corticule granules.



This response gained marking points one and two, they did not extend their answer to suggest why there may differences in the protein/receptor.

- (b) When a sperm cell arrives at an egg cell surface it binds to a receptor on the egg cell surface membrane.

The diagram shows a sperm cell binding to a complementary shaped receptor on the egg cell surface membrane.



(Source: adapted from <https://www.sciencedirect.com/topics/nursing-and-health-professions/zona-pellucida-glycoprotein>)

- (i) Suggest why some sperm cells may not be able to bind to the sperm receptor on the egg cell surface membrane.

(3)

The receptor on the sperm cell may not be complementary from a mutation in meiosis. If another sperm cell already attached to a receptor, the cortical reaction begins which damages the / destroys the sperm binding sites preventing further binding. Zona pellucida also hardens preventing further acrosome reaction, change in charge ~~repels~~ repels approaching sperm.



This response gave multiple suitable suggestions, gained all three marking points and scored 3 marks.

Question 8(b)ii

Candidates were asked to explain how more sperm cells are prevented from entering the egg cell.

A significant number of candidates did not recognise that this was referring to the cortical reaction; instead vague answers referring to polyspermy were seen.

In answers which did explain the cortical reaction, most candidates gained marking point two for stating that the cortical reaction hardens the zona pellucida. Few gave enough detail of the cortical reaction to gain a further mark.

Higher-level responses considered the context of the question and applied their knowledge of the cortical reaction to the given protein molecules in the question, for example the sperm receptor.

(ii) Explain how more sperm cells are prevented from entering the egg cell.

(2)

After the ^{male} nucleus fuses with the egg cell nucleus, cortical granules are released which fuses with the zona pellucida which hardens the zona pellucida therefore preventing polyspermy.



This is an example of a common response which scored just one mark for the second marking point.



Consider the level of detail in your response - have you fully explained how something happens?

(ii) Explain how more sperm cells are prevented from entering the egg cell.

(2)

After fertilisation, cortical reactions takes place, cortical granules fuses with egg cell membrane releasing enzymes by exocytosis, ~~causing~~ causing zona pellucida to harden and thicken forming tough fertilisation layer and acrosomes can no longer digest zona pellucida preventing polyspermy.



This response gained marking points one and two.

Question 8(c)i

Candidates were provided with information regarding three species of reef urchin.

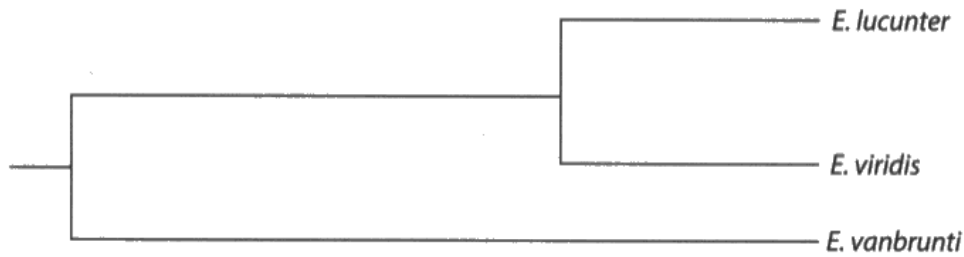
Candidates were expected to analyse the given information and use it throughout both 8ci and 8cii.

Candidates were asked to explain how scientists could have determined that *E. viridis* was more closely related to *E. lucunter* than to *E. vanbrunti*.

Most candidates knew that the scientists would need to compare sequences of named biological molecules, with DNA and mRNA being the most commonly seen molecules.

Fewer candidates could explain how this information could be used to determine that *E. viridis* was more closely related to *E. lucunter* than to *E. vanbrunti*.

The diagram shows the relationship between these three species.



- (i) Explain how scientists could have determined that *E. viridis* was more closely related to *E. lucunter* than to *E. vanbrunti*.

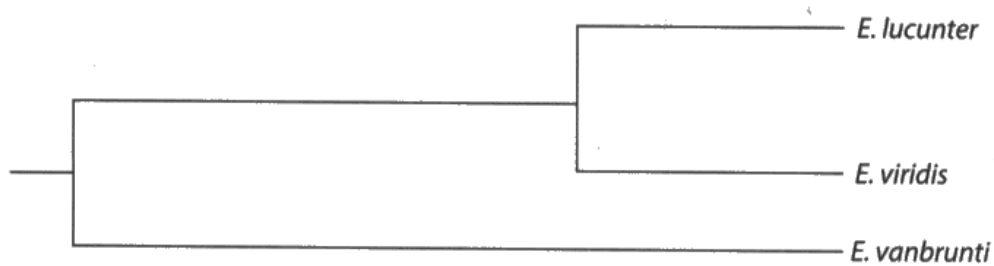
(2)

by there phenotype or there genetics
also by how they reproduce
or where they live.



This answer did not contain sufficient detail for marking point one.

The diagram shows the relationship between these three species.



- (i) Explain how scientists could have determined that *E. viridis* was more closely related to *E. lucunter* than to *E. vanbrunti*.

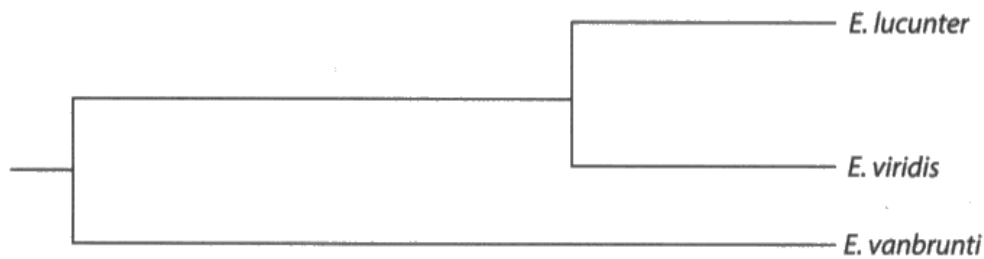
(2)

by molecular phylogeny comparing DNA and RNA
comparing genotype ~~of~~ and ~~phen~~ type of both *E. viridis*,
E. lucunter and *E. vanbrunti*



This response gained marking point one only. They have not explained how this evidence would have enabled the scientists to determine which species were more closely related.

The diagram shows the relationship between these three species.



- (i) Explain how scientists could have determined that *E. viridis* was more closely related to *E. lucunter* than to *E. vanbrunti*.

(2)

~~the~~ do molecular phylogeny and analyse what molecules like DNA
~~they~~ their gene makes, if *E. viridis* has more similarities
to *E. lucunter* ~~than~~ than *E. vanbrunti* in terms of molecules made,
E. viridis is more closely related
or see if they have ~~same~~ ^{similar} kind of phenotypes



This is an example of a response which scored two marks.

Question 8(c)ii

This was the second level-based question on this paper. Candidates were asked to explain how reproductive isolation could have led to the formation of these three reef urchin species.

Candidates were previously provided with information regarding these three species of reef urchin and were expected to analyse the given information and use it throughout their answer. Answers which did not apply their knowledge to the given context were limited in the marks they could achieve.

The most common way that candidates accessed level one was by giving a simple generic speciation explanation linked to geographical isolation. Candidates explained how genetic variation and different selection pressures resulted in natural selection.

Candidates often accessed level two by linking these aspects to the accumulation of different genetic information in the different populations, often linking this back to reproductive isolation. Responses were often detailed explanations of how speciation could have resulted from reproductive isolation but were not linked to the provided context.

Candidates who applied the given information from question 8 to their detailed speciation answer, as they were directed to do in the question, were able to access level three. These responses clearly linked the information from the map, phylogenetic tree, as well as the varying proteins from 8(a) and 8(b) to give the greater depth and sustained line of scientific reasoning required.

*(ii) Explain how reproductive isolation could have led to the formation of these three species.

Use your own knowledge and **all** the information from question 8 to support your answer.

(6)

The three kind of sea urchin live in different habitats. So they have different niche and are facing different selection pressure. As a result, they have evolved different phenotypes, and individuals who carries this gene have more chance to survive, therefore the gene is passed on. Different species are formed. And because different species cannot have fertilizable offspring, so they have to fertilize with same species.

This level one response made a basic explanation covering some aspects of speciation.

- * (ii) Explain how reproductive isolation could have led to the formation of these three species.

Use your own knowledge and **all** the information from question 8 to support your answer.

(6)

- due to geographical locations
 - which means different environments
 - hence different Selection ^{Pressure.} ~~Pressure.~~
-
- Mutations may have occurred
 - There fore new advantageous alleles may have formed.
 - leading to the survival of the fittest
 - These alleles will then go down to

the offspring during reproduction.

- Hence raising the advantageous allele frequency.

- Therefore can give rise to a new species.

- new species are determined when the 2 species breed together and is not able to produce a fertile offspring.

- it could also be due to the ~~gene~~^{allele} being isolated therefore the gene frequency of the species will decrease leading to the new genes formed be way different than it is from the original species.

(Total for Question 8 = 16 marks)

TOTAL FOR PAPER = 80 MARKS



This is an example of a speciation explanation which is not linked to the provided context and was limited to level two.

- *(ii) Explain how reproductive isolation could have led to the formation of these three species.

Use your own knowledge and **all** the information from question 8 to support your answer.

(6)

• Reproductive isolation is when two species can not breed with each other due to their ~~an~~^{common} ancestor, species being geographically isolated from each other. *E. vanbrunti* is located the most in the Pacific ocean, while *E. lucunter* is present in both Caribbean sea & Atlantic ocean and *E. viridis* is only present in the Caribbean sea (most of it). Since *E. vanbrunti* and *E. lucunter* are in different oceans, the oceans will experience different environments, and so the

urchins adapt to these through their advantageous alleles against the selection pressures. Since ~~the~~ all urchin types are separated, they can no longer reproduce with genetically different (variation in alleles) urchins. So, sperm cells from differently located urchins can not bind with the receptor on the egg cell. This is because once they are geographically isolated, and they develop their own alleles, the proteins on the egg cell would change. So, egg cells from a different urchin group can't fuse with sperm cells from other urchin groups as they are not compatible due to evolution as allele frequencies of advantageous alleles have increased. There might be some fertilisation between viridis & unicorn but only slightly as viridis is densely populated in the ^{centre of} Caribbean, so unicorn will need to travel large distances which it won't do, hence why it evolves in its own habitat.

(Total for Question 8 = 16 marks)

TOTAL FOR PAPER = 80 MARKS

The offspring produced will have new combination of advantageous alleles, which are unique compared to other urchins in other locations. Urchins without these advantageous alleles could die so the urchins that were from the same species do not survive whilst the new offspring leads to the formation of new species. So, they won't reproduce with urchins in a different location so they ~~were~~ are characterized as separate species since the offspring, if fertilisation is successful is infertile.



This is an example of a level three response. The candidate has applied the given information from the map and earlier aspects from question 8 to their detailed speciation explanation.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Read the whole question carefully to ensure you do not miss questions.
- You should take into account the command words as well as the context given. Answers which do not match the command words or do not relate to the given context will not gain high marks.
- Information provided in the introduction to questions is provided for a specific reason. Read it carefully and analyse what information will be needed to provide a high-level response to the question being asked.
- Do not try and make a mark scheme you have learnt from a previous paper fit a different question with different context and command words.
- Study all of the mathematical skills that are non emboldened in the specification.
- Make sure you include your working with all calculations. If rounding is necessary, make sure that this is done correctly. Check to see what format you are expected to present your answer in, eg, standard form or a certain number of significant figures.
- Understand the meaning of key terminology used in the specification.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:
<https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html>

