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Examiners' Report
June 2025

GCE Biology B 9BI0 02

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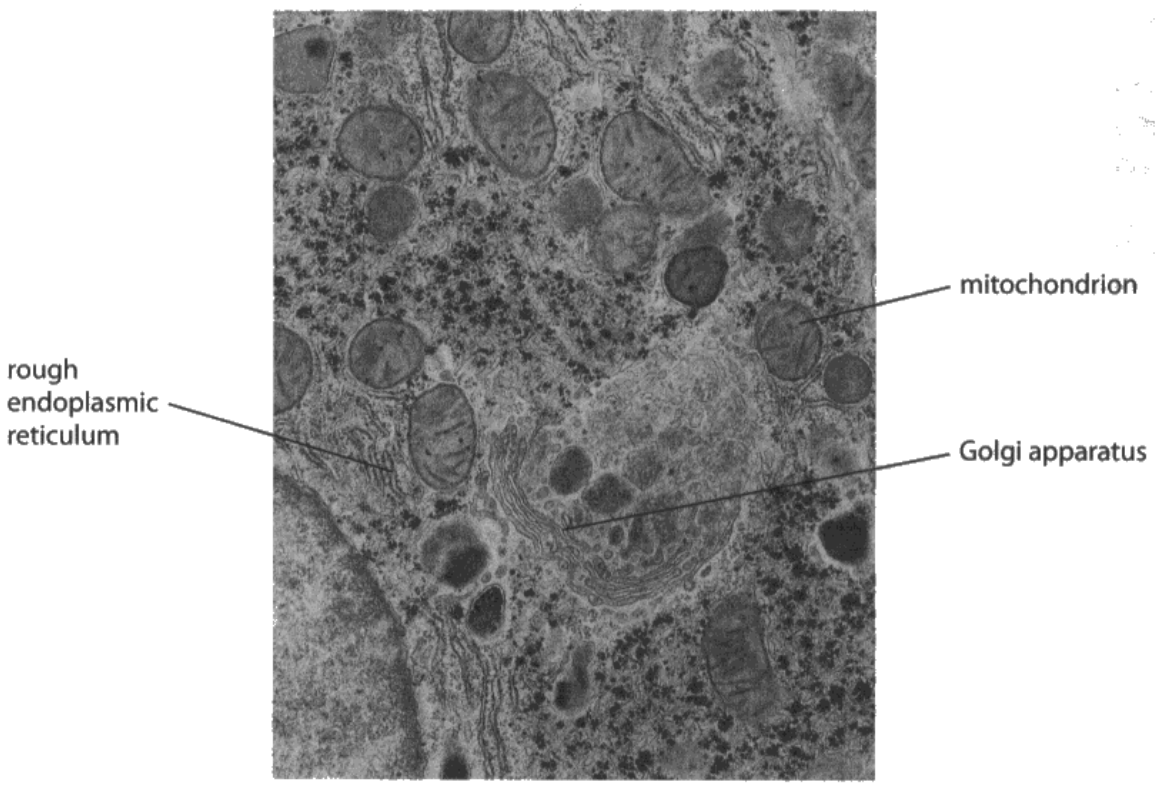
Introduction

The examiners were very impressed with the high standard of many of the scripts seen. Candidates and centres should be commended on their hard work whilst studying the course and in preparing for the examination. Many candidates used high level vocabulary accurately and wrote answers commensurate with A-Level standard. Data analysis was generally improved compared with other series and most candidates understood the differences between the different command words used in questions. The examiners were pleased to note that when asked to 'compare and contrast', most candidates correctly gave both similarities and differences and set out their answer correctly. The paper contained a Spearman's rank statistical calculation – most candidates were able to correctly calculate the coefficient but a significant number were unsure how to use it to interpret the data. Mathematical skills were generally very strong although some candidates confused significant figures with decimal places. Both level-based questions were well answered with most gaining at least three marks for both and many going on to gain more than four. When discussing data for the longer, level-based, questions, candidates should ensure that they consider all pieces of data, describe the patterns and also suggest explanations for the patterns. Typical mistakes that candidates made included: using vocabulary inaccurately, not exploring data fully, and not being precise when describing data patterns.

Question 1(a)

This first question asked candidates to give the functions of mitochondria, rough endoplasmic reticulum (rER), and Golgi apparatus. Many candidates gave excellent descriptions and often gained at least two marks. Strong answers explained that mitochondria perform aerobic respiration and produce ATP, the rER synthesises proteins, and the Golgi modifies proteins. Many answers with excellent detail were seen with some candidates giving functions such as the role of the Golgi in the glycosylation of proteins and forming the quaternary structures of protein. Where candidates did not score all three marks it was typically for giving vague terms such as 'mitochondria were the powerhouses of the cell' and confusing the functions of the Golgi with rER. Common incorrect answers seen included, the 'production of energy' by the mitochondria, rER synthesising ribosomes or modifying proteins.

1 The photograph shows part of a liver cell, as seen using an electron microscope.



(Source: © Keith R. Porter/SCIENCE PHOTO LIBRARY)

(a) Describe the roles of the labelled organelles in a liver cell.

(3)

The role of the rough endoplasmic reticulum is to synthesise protein.
The role of the Golgi apparatus is to ~~mmt~~ modify ~~protein by a~~
and package protein into vesicle
The role of the mitochondrion is to carry out respiration and produce ATP.

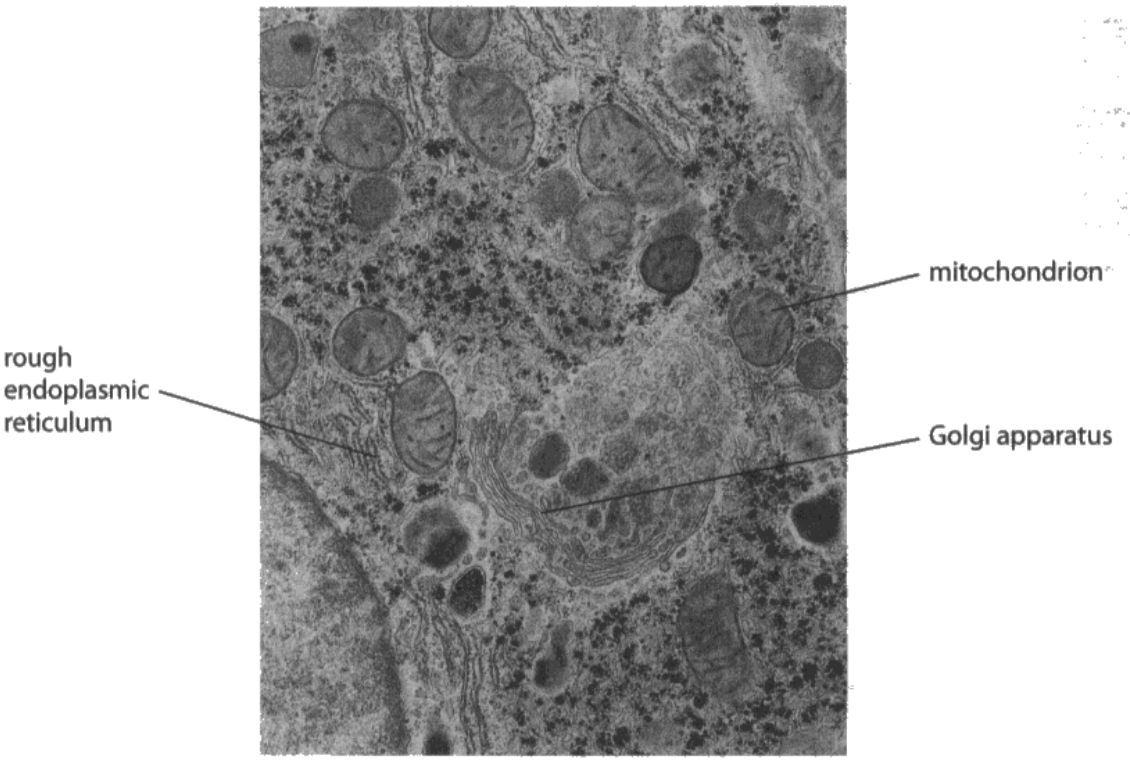
ResultsPlus
Examiner Comments

This answer gained all three marks. The candidate has correctly stated that mitochondria produce ATP, the rER synthesises protein, and the Golgi modifies proteins.

ResultsPlus
Examiner Tip

Don’t state the mitochondria 'make energy' and make sure answers have A-Level depth, eg don’t state things like 'powerhouse of the cell.'

1 The photograph shows part of a liver cell, as seen using an electron microscope.



(Source: © Keith R. Porter/SCIENCE PHOTO LIBRARY)

(a) Describe the roles of the labelled organelles in a liver cell.

(3)

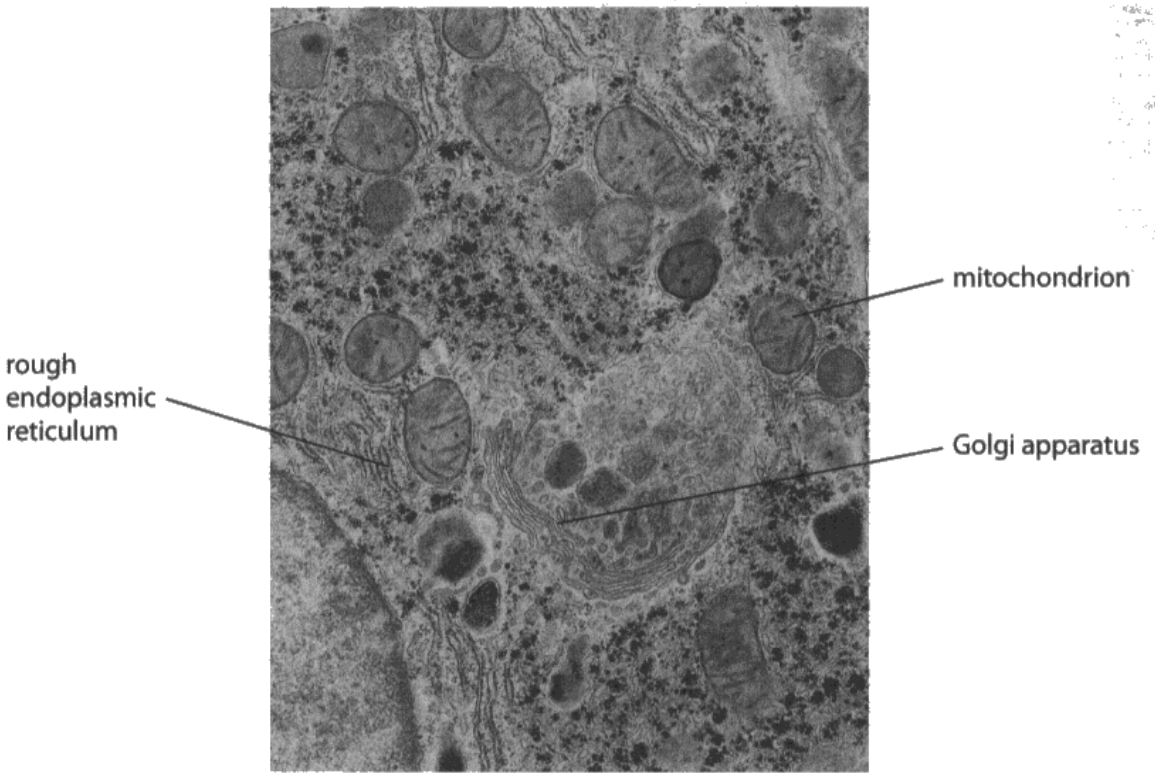
There are lots of mitochondria in this cell. Mitochondria is present to generate ATP through aerobic respiration for active transport in the liver. The rough endoplasmic reticulum contains ribosomes ~~in its cisternae~~ which are used in the translation of mrna into a polypeptide chain; this chain folds to form proteins such as enzymes ~~used in the~~ like amylase for the breakdown of ~~glucose~~ starch. The golgi apparatus ~~packages~~ modifies and packages these proteins into vesicles

ResultsPlus
Examiner Comments

This is an excellent answer that gained all three marks. The candidate has given accurate

and detailed descriptions of the functions of all three organelles.

1 The photograph shows part of a liver cell, as seen using an electron microscope.



(Source: © Keith R. Porter/SCIENCE PHOTO LIBRARY)

(a) Describe the roles of the labelled organelles in a liver cell.

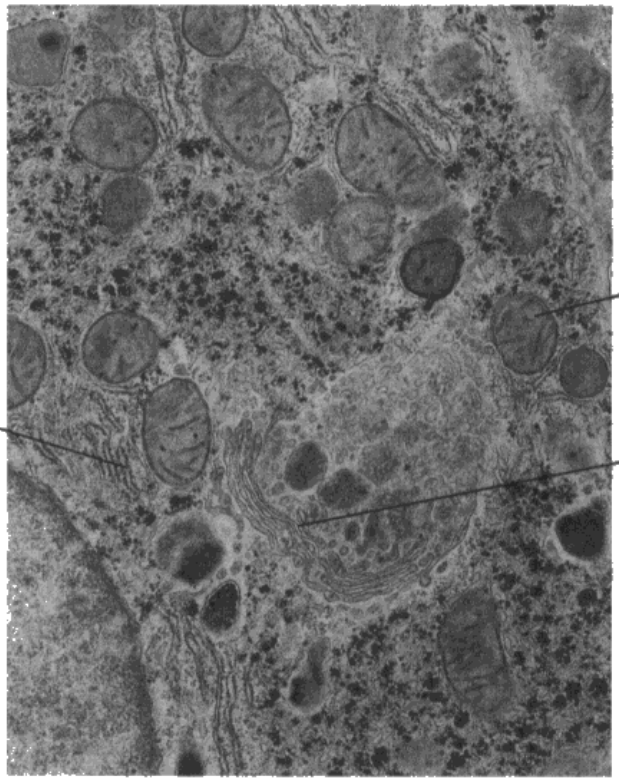
(3)

The mitochondria provide an energy source in the form of ATP. The Golgi helps with the transfer of proteins to the vesicles as it packages the amino acids. The RER helps move mRNA to the ribosomes. ~~to be t~~

ResultsPlus
Examiner Comments

This answer gained one mark for the function of the mitochondria in producing ATP. The functions given for the rER and Golgi are incorrect.

1 The photograph shows part of a liver cell, as seen using an electron microscope.



(Source: © Keith R. Porter/SCIENCE PHOTO LIBRARY)

(a) Describe the roles of the labelled organelles in a liver cell.

(3)

Rough endoplasmic reticulum is a membrane covered in ribosomes which helps provide ATP for the cell

Golgi Apparatus is where DNA ~~transcription~~ translation takes place

Mitochondrion are used for ATP synthesis

ResultsPlus
Examiner Comments

This answer gained one mark for the function of the mitochondria. The functions stated for the Golgi and rER are both incorrect.

Question 1(b)(i)

This relatively straightforward question asked candidates to describe the process of DNA replication. Many excellent, detailed answers were seen that gave correct functions of DNA helicase, DNA polymerase, and DNA ligase. Many candidates gained at least two marks and most had an understanding of the process of DNA replication. Common errors included, confused DNA replication with transcription, using inaccurate terminology such as referring to amino acids rather than nucleotides, and giving incorrect functions of the enzyme, for example suggesting that polymerase forms hydrogen bonds between adjacent nucleotides. Strong answers used detailed terminology confidently and accurately, such as referring to the production of the phosphodiester bonds between adjacent nucleotides and some even correctly referred to the role of DNA ligase in joining Okazaki fragments.

(b) Hepatitis B is a DNA virus that infects liver cells. The DNA of the virus replicates inside liver cells.

(i) Describe the process of DNA replication.

(3)

- DNA helicase unwinds the 2 strands of DNA by breaking the Hydrogen bonds

- then DNA polymerase runs in an opposite direction, joining free nucleotides with the template strand of DNA

- finally, DNA ligase sticks the 2 strands (one old + one new) together to form a semi-conservative double helix of DNA.

ResultsPlus
Examiner Comments

This answer gained one mark for the function of DNA helicase. The candidate has not used accurate terminology when stating the functions of polymerase and ligase – the candidate clearly understands that the two enzymes have a role in replication but has not described them accurately.

ResultsPlus
Examiner Tip

Make sure that you use technical language accurately – it is not enough to just make reference to key terms without the correct context.

(b) Hepatitis B is a DNA virus that infects liver cells. The DNA of the virus replicates inside liver cells.

(i) Describe the process of DNA replication.

(3)

- DNA strand is unzipped using DNA helicase
- ~~Fast~~ Translation occurs. An mRNA strand is formed from the DNA strand from free floating nucleotides, creating a complementary strand
- The mRNA leaves the nucleus and travels through the cytoplasm until it reaches a ribosome

ResultsPlus
Examiner Comments

This answer gained one mark for the function of helicase. The candidate has confused protein synthesis with DNA replication.

(b) Hepatitis B is a DNA virus that infects liver cells. The DNA of the virus replicates inside liver cells.

(i) Describe the process of DNA replication.

(3)

The DNA is unzipped along the line of hydrogen bonds causing the two strands of DNA to unravel forming singu Strands of DNA this is caused by enzyme DNA helicase. these Strands ~~all~~ act as templates for the new DNA Strands the exposed DNA bases attract free DNA nucleotides which hydrogen bond onto the exposed DNA bases following complementary base pairing rules
the DNA polymerase catalyses the linking of nucleotides to form phosphodiester bonds
DNA ligase catalyses the linking of Okazaki fragments.

ResultsPlus
Examiner Comments

This excellent answer has all four mark points and gains three marks (maximum). The candidate correctly describes the functions of DNA polymerase, ligase and helicase and describes the complementary base pairing. The answer uses detailed terminology throughout and is extremely accurate.

(b) Hepatitis B is a DNA virus that infects liver cells. The DNA of the virus replicates inside liver cells.

(i) Describe the process of DNA replication.

(3)

- Helicase unzips double helix of DNA and breaks hydrogen bonds between the two strands.
- Free nucleotides in cytoplasm are attracted to exposed bases, complementary bases form hydrogen bonds
- DNA polymerase works in 5' to 3' direction, and ~~proteases~~ phos builds up the sugar phosphate backbone. Ligase joins the sections of new DNA
- Daughter strand and template strand wind back into double helix - replication is semiconservative

ResultsPlus
Examiner Comments

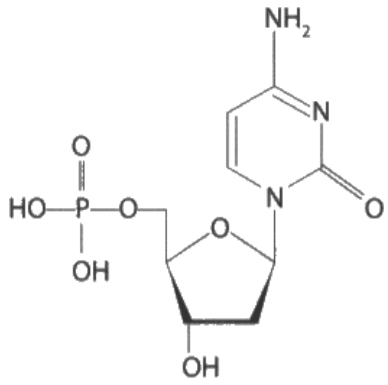
This excellent answer also gained all three marks. The candidate correctly describes the roles of helicase, polymerase and ligase and describes the binding of complementary nucleotides. The answer is detailed and accurate.

Question 1(b)(ii)

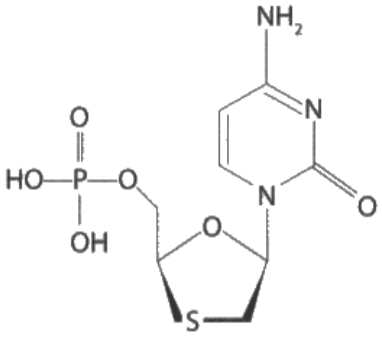
This data analysis question presented candidates with a nucleotide variant that had a carbon atom (and OH group) replaced with a sulfur and asked candidates why this nucleotide would prevent DNA replication. Many candidates correctly identified how the variant nucleotide differed from the normal nucleotide but fewer went on to explain that phosphodiester bonds would not be able to form and so the sugar-phosphate backbone of DNA would also not form. Some candidates stated that the sulfur replaced an OH group when the sulfur in fact replaced a carbon group that had an OH group attached.

(ii) The drug lamivudine is used to treat infections by the hepatitis B virus. It causes the production of altered nucleotides containing cytosine.

The diagram shows a normal nucleotide and an altered nucleotide.



normal nucleotide



altered nucleotide

Explain how lamivudine reduces replication of the hepatitis B virus in liver cells.

(2)

The ~~other~~ altered nucleotide has had its deoxyribose is modified, with a carbon missing a sulfur. This would prevent the formation of phosphodiester bonds between nucleotides and prevent the synthesis of hepatitis B genetic material. This would remove the ability to assemble new viral particles using the host cells machinery.

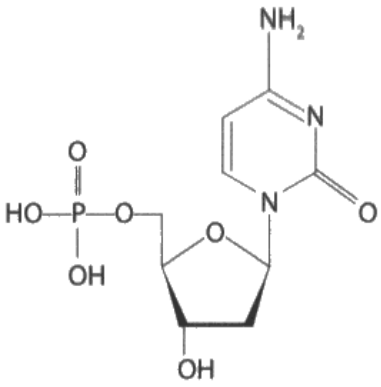
(Total for Question 1 = 8 marks)

ResultsPlus
Examiner Comments

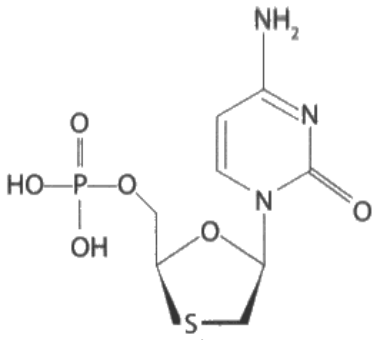
This answer gained one mark for stating that phosphodiester bonds would not form. The candidate has not clearly stated that this is due to the lack of the OH or replacing the carbon with a sulfur.

(ii) The drug lamivudine is used to treat infections by the hepatitis B virus. It causes the production of altered nucleotides containing cytosine.

The diagram shows a normal nucleotide and an altered nucleotide. AT = 2



normal nucleotide



altered nucleotide

Explain how lamivudine reduces replication of the hepatitis B virus in liver cells.

(2)

as the ~~OH~~ Carbon 3 with OH group is replaced by Sulfur in the sugar ring (~~de~~ deoxyribose *1), sugar-phosphate backbone cannot be formed (phosphodiesterbond). Therefore it terminates the DNA chain, so DNA replication stops as the DNA polymerase can't ~~bind~~ join ~~them~~ the adjacent nucleotides *1 in altered nucleotide.

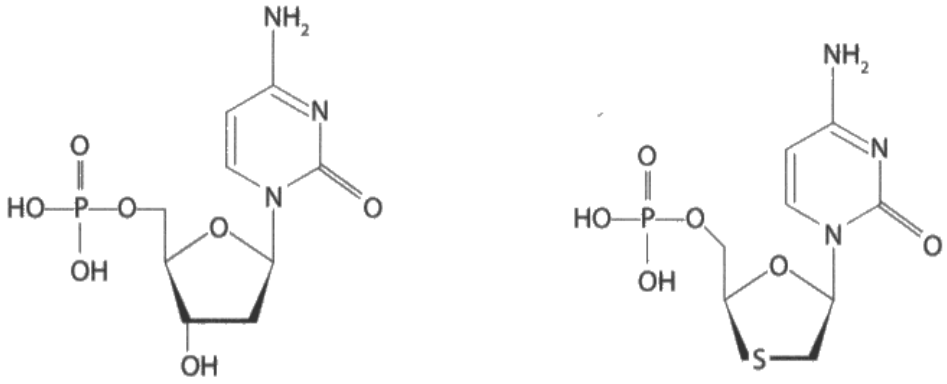
ResultsPlus
Examiner Comments

This excellent answer gained both marks for correctly identifying the difference and going

on to state that this means that phosphodiester bonds will not form.

(ii) The drug lamivudine is used to treat infections by the hepatitis B virus. It causes the production of altered nucleotides containing cytosine.

The diagram shows a normal nucleotide and an altered nucleotide.



normal nucleotide **altered nucleotide**

Explain how lamivudine reduces replication of the hepatitis B virus in liver cells.

(2)

In a normal nucleotide, there's a -OH group attached to carbon atom 3, which is where it would bond to the next nucleotide in a strand. The altered nucleotide produced by lamivudine has an S atom in place of carbon 3, so phosphodiester bonds can't form in viral DNA replication.

ResultsPlus
Examiner Comments

This excellent answer gained both marks for correctly stating the difference between the two molecules and going on to state that phosphodiester bonds will not form.

Question 2(a)(ii)

This question required candidates to give a description of the events of prophase I in meiosis. Strong responses gave detailed answers and often referred to the breakdown of the nuclear membrane, the movement of centrioles to the poles of the cell, the condensing of chromosomes, the formation of bivalents and the crossing over between homologous chromosomes. Candidates should be careful to refer to homologous chromosomes rather than identical chromosomes. Some candidates incorrectly referred to independent assortment and others referred to the binding of chromosomes to the spindle. Some candidates also incorrectly referred to the uncoiling of chromosomes causing them to become visible.

(ii) Meiosis is involved in oogenesis.

Describe the events of prophase I during oogenesis.

(3)

The chromosomes condense and becomes visible.

The nuclear envelope start to break down.

~~The chromosomes~~ Homologous chromosomes may overlap and crossing over occur, exchange genetic material.

The overlap point is called chiasma.

ResultsPlus
Examiner Comments

This answer gained three marks. The candidate correctly states that chromosomes condense and become visible, the nuclear envelope breaks down and crossing over occurs between homologous chromosomes at chiasmata.

(ii) Meiosis is involved in oogenesis.

Describe the events of prophase I during oogenesis.

(3)

- Chromosomes condense and become visible.
- ~~At~~ The nuclear envelope breaks down.
- ~~C~~ Recombination occurs between homologous chromosomes so genetic material is exchanged.
- The ~~sp~~ centrioles migrate to opposite poles of the cells and spindle fibres start to form.

ResultsPlus
Examiner Comments

This excellent answer gained three marks. The candidate correctly states that the chromosomes condense and become visible, the nuclear envelope breaks down, recombination occurs between homologous chromosomes and the centrioles migrate to opposite ends of the cell.

(ii) Meiosis is involved in oogenesis. PMAT

Describe the events of prophase I during oogenesis.

(3)

The chromosomes begin to move towards the middle of the cell. Spindle fibres begin to form. These help to arrange the chromosomes. The chromosomes begin to ~~t~~ line up on the equator of the cell.

ResultsPlus
Examiner Comments

This answer gained only one mark for the statement that spindle fibres begin to form. The

candidate has confused prophase with metaphase.

4 (ii) Meiosis is involved in oogenesis.

Describe the events of prophase I during oogenesis.

PMAT

(3)

prophase means the chromatin will condense into visable chromosomes, centrioles will become visable and attach to centresomes.

Organelles will double

ResultsPlus
Examiner Comments

This answer gained one mark for correctly stating that the chromatin condenses into visible chromosomes.

Question 2(a)(iii)

This question required candidates to compare and contrast the events of oogenesis with spermatogenesis. Most candidates gained at least one mark and it was pleasing to see that most candidates now appreciate that both similarities and differences are required and that they need to structure their answers so that there are separate sections to show similarities and differences. Common correct similarities included both processes requiring both mitosis and meiosis, both starting with primordial germ cells or stem cells. Many also correctly stated that both produce haploid, genetically different gametes. Common differences that were credited included the idea that spermatogenesis produces four gametes whilst oogenesis produces only one and polar bodies, and that oogenesis is arrested at prophase I and metaphase II.

(iii) Compare and contrast the process of oogenesis with spermatogenesis.

(3)

Both oogenesis and spermatogenesis begin with a primordial germ cell and undergo mitosis first, but in oogenesis only one oogonium survives and all others degenerate, whereas almost all spermatogonia survive and mature into spermatocytes. Spermatogenesis occurs from puberty onwards throughout the rest of life, whereas oogenesis occurs in utero in the foetus up until the first meiotic division, and second meiotic division occurs during fertilisation. Both involve meiosis and produce genetically varied haploid gametes. Spermatogenesis produces many, very small spermatozoa whereas oogenesis forms far fewer, much larger ova.

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Examiner Comments

This answer gained all three marks. The candidate correctly states that both processes involve both mitosis and meiosis, that both start with primordial germ cells, and the idea that spermatogenesis begins in puberty whilst oogenesis begins in utero. The candidate also states that idea that only one oocyte is produced and that meiosis only finishes at fertilisation.

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Examiner Tip

If asked to 'compare and contrast' make sure that you have a section listing the similarities and a section listing the differences.

(iii) Compare and contrast the process of oogenesis with spermatogenesis.

(3)

Both produce gametes. Both involve meiosis. Both start with germ cells. Oogenesis produces 1 female gamete (ovums) whereas spermatogenesis produces 4 male gametes (sperm). oogenesis involves polar bodies but spermatogenesis does not. Spermatogenesis can occur throughout a males life whereas oogenesis only occurs until menopause. Both products of oogenesis and spermatogenesis are haploid.

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Examiner Comments

This answer gained all three marks. The candidate correctly states that both start with germ cells, oogenesis produces one gamete but spermatogenesis produces four, and both produce haploid gametes.

(iii) Compare and contrast the process of oogenesis with spermatogenesis.

(3)

Both undergo mitosis
Both

Spermatogenesis produces 4 specialised cells while Oogenesis produces 1.
Oogenesis produces 3 polar bodies (that die off) while Spermatogenesis doesn't.

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Examiner Comments

This answer gained only one mark for correctly stating that four sperm are produced whilst only one egg is produced.

(iii) Compare and contrast the process of oogenesis with spermatogenesis.

(3)

Oogenesis forms only one ovum, whilst spermatogenesis forms many spermatozoa. Both oogenesis and spermatogonia involve mitosis and meiosis. The process of oogonia occurs before birth, whilst spermatogenesis occurs after puberty.

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Examiner Comments

This answer gained all three marks for stating that both involve mitosis and meiosis, only one ovum is formed and the idea of the difference in times that the processes occur.

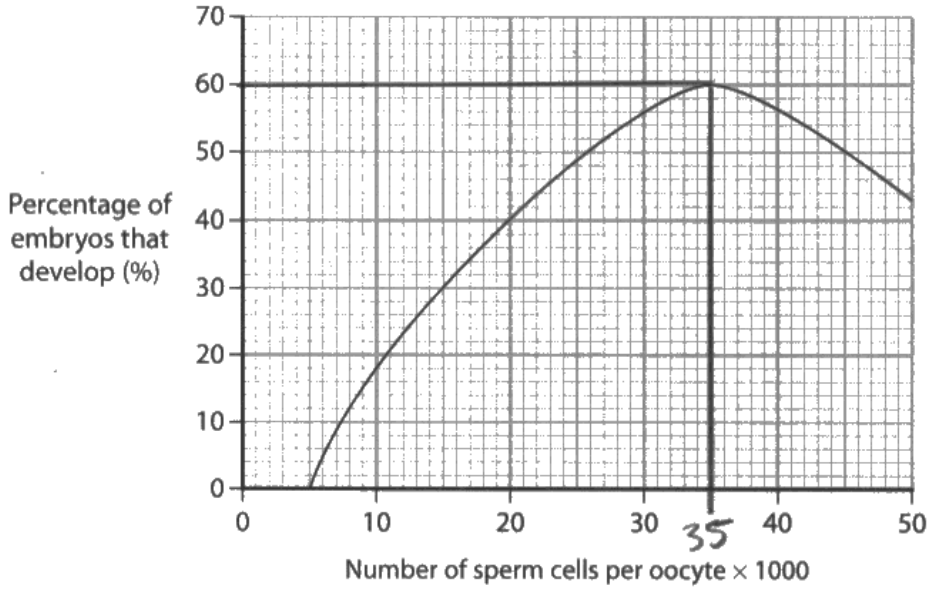
Question 2(b)(i)

This mathematical question required candidates to read values from a graph to calculate the number of sperm cells that would be required to fertilise four oocytes. Many candidates were able to extract the data from the graph correctly and use it to derive the correct final answer. The main error was to not multiply the answer by 1000.

(b) During in vitro fertilisation (IVF), oocytes are fertilised with sperm cells in a culture medium.

If more than one sperm cell fertilises an oocyte, the embryos do not develop.

The graph shows the effect on the production of embryos that develop when different numbers of sperm cells are added to oocytes during IVF.



(i) Calculate the number of sperm cells that need to be added to four oocytes so that 60% of embryos develop.

(1)

35 x 4 = 140

Answer 140

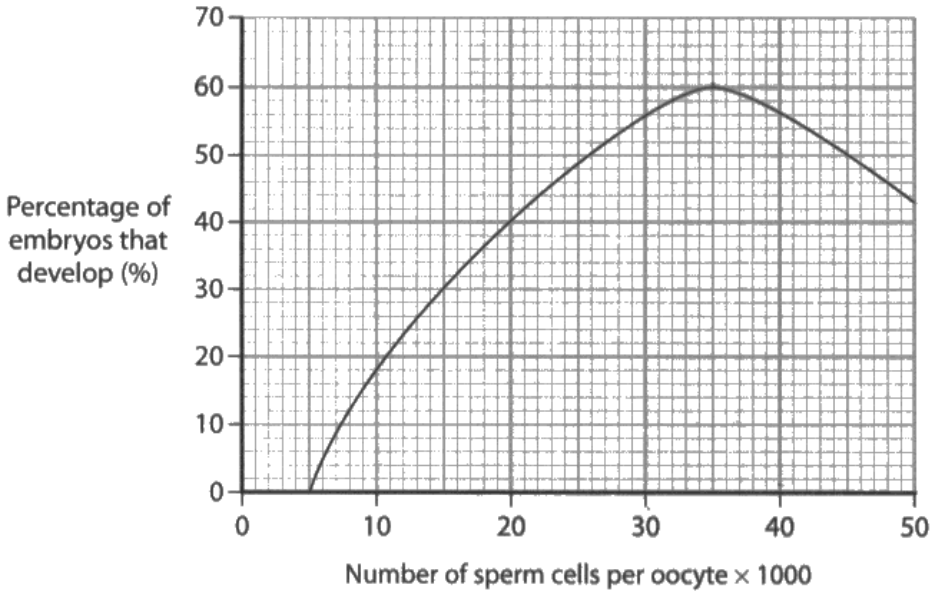
ResultsPlus
Examiner Comments

This answer did not gain the mark as the candidate has not multiplied the answer by 1000.

(b) During in vitro fertilisation (IVF), oocytes are fertilised with sperm cells in a culture medium.

If more than one sperm cell fertilises an oocyte, the embryos do not develop.

The graph shows the effect on the production of embryos that develop when different numbers of sperm cells are added to oocytes during IVF.



(i) Calculate the number of sperm cells that need to be added to four oocytes so that 60% of embryos develop.

(1)

At 60% = (35 × 1000 per oocyte) × 4
= 140000

Answer 140000

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Examiner Comments

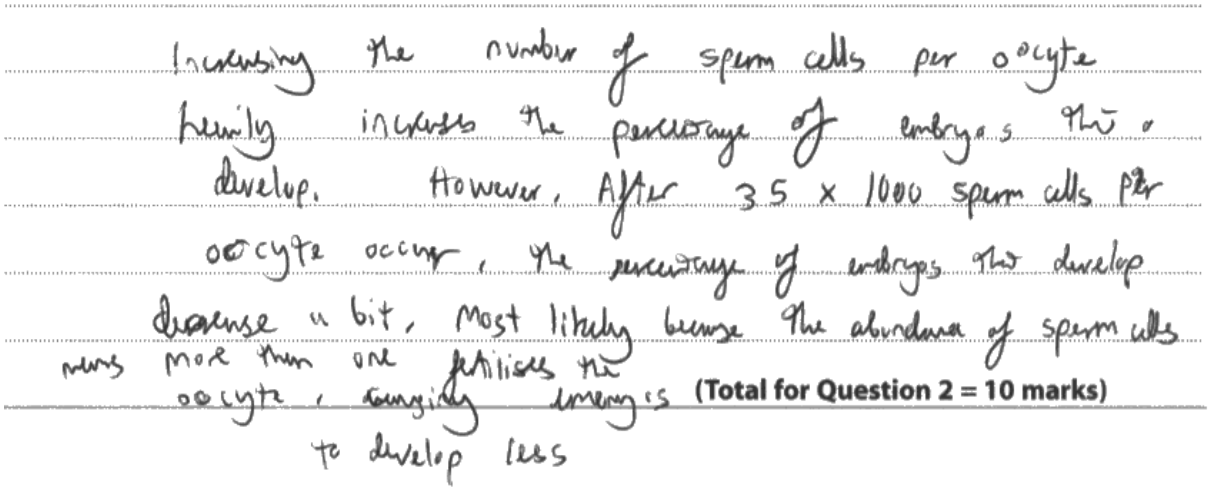
This correct answer gained one mark. The candidate has shown all their working which is an example of good practice.

Question 2(b)(ii)

This question required candidates to use their knowledge of fertilisation to explain the effects of increasing the sperm concentration on the percentage of embryos that develop. Many candidates correctly described the pattern of an increase and decrease, including the turning point on the graph but fewer went on to gain the second mark for explaining the reason for the increase and decrease. The most frequent correct answer was to state the incidence of polyspermy increases at high sperm concentrations. A few candidates correctly stated that with low concentrations of sperm there would be fewer acrosome reactions and so the sperm would be less able to reach the membrane of the oocyte.

(ii) Analyse the data to explain the effects of increasing the number of sperm cells per oocyte on the percentage of embryos that develop.

(2)



(Total for Question 2 = 10 marks)

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Examiner Comments

This answer gained two marks for correctly stating the increase and decrease and going on to state that at high concentrations there is a high chance of two sperm cells fertilising the oocyte.

(ii) Analyse the data to explain the effects of increasing the number of sperm cells per oocyte on the percentage of embryos that develop.

(2)

Increasing the number of sperm cells up to 35 x1000 per oocyte increases the percentage ~~of~~ of embryos will form, however increasing above 35 x1000 sperm cells per oocyte tends to decrease the percentage of embryos that develop.

ResultsPlus
Examiner Comments

This answer gained one mark for describing the pattern but gave no creditworthy reason for the results.

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Examiner Tip

Make sure that you give reasons for patterns in data if asked for an explanation.

(ii) Analyse the data to explain the effects of increasing the number of sperm cells per oocyte on the percentage of embryos that develop.

(2)

As the number of sperm cells per oocyte increases, the percentage of embryos that develops also increases. However when the number of sperm cells per oocyte reaches 35000, the percentage of embryos that develop starts to decrease. This may be because more than one sperm is fertilising the oocyte resulting in the embryos not developing.

(Total for Question 2 = 10 marks)

ResultsPlus
Examiner Comments

This answer gained two marks for correctly stating that pattern and that there is a higher risk of more than one sperm fertilising the egg when the concentration is high.

Question 3(a)(ii)

This AO1 question required candidates to describe the myogenic stimulation of the heart. Many excellent answers were seen that gained all three marks. Strong answers referred to the role of the SAN in causing the depolarisation of the atria, atrial contraction, the role of the delay at the AVN and the passing of the depolarisation along the bundle of His / Purkinje fibres to the apex and then up the ventricle walls to stimulate contraction from base upwards. Common errors included confusing the sequence of the SAN and AVN, not referring to the bundle of His or Purkinje fibres, and not stating that the depolarisation passes up the ventricle walls. Some candidates incorrectly referred to the role of the autonomic nervous system in regulating heart rate – the question was focused on myogenic stimulation of the heart.

(ii) Describe how myogenic stimulation maintains the heart rate of the student when at rest.

(3)

Myogenic stimulation means that the cardiac cells can generate their own impulses ~~without a~~ and keep contracting in synchrony without external stimulation from the central nervous system, producing intrinsic rhythmicity. The sinoatrial node in the right atrium generates a wave of depolarisation which travels across the atria, leading to atrial systole, then to the AVN and down into the septum, through the Bundle of His and then splits into two across the purkyne fibres so ventricular systole occurs from the apex of the ventricles upwards. Once ventricles have relaxed, SAN sets up another wave of depolarisation, leading to another heart beat, process repeats continuously.

ResultsPlus
Examiner Comments

This strong answer gained all three marks. The candidate correctly states that the SAN starts a wave of depolarisation that results in atrial systole, the impulse passes along the bundle of His and then moves upward through the ventricles. There is excellent, accurate use of key terminology.

ResultsPlus
Examiner Tip

Organise description answers into a natural sequence if possible.

(ii) Describe how myogenic stimulation maintains the heart rate of the student when at rest.

(3)

Heart is able to initiate its own contraction via recieving oxygenated blood from the coronary artery.

This supplies the heart with enough O_2 and blood volume to beat whilst transporting oxygen to other areas & the body.

ResultsPlus
Examiner Comments

This answer gained no marks. The candidate has not given an A-Level standard of detail in their answer.

(ii) Describe how myogenic stimulation maintains the heart rate of the student when at rest.

(3)

→ There's a delay when polarisation of impulse gets to the atrioventricular node

→ This allows for the blood to settle within the heart.

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Examiner Comments

This answer gained one mark for the idea that there is a delay at the AVN.

(ii) Describe how myogenic stimulation maintains the heart rate of the student when at rest.

(3)

The impulse begins at the sino Atrial Node (SAN) which allows depolarisation of the atria. The impulse then travels to the Atrio Ventricular Node (AVN) where it gets delayed. The impulse then travels to the bundle of His, allowing depolarisation of the ventricle. The impulse then reaches the purkinjie fibres, allowing the heart to fully contract.

ResultsPlus
Examiner Comments

This excellent, detailed answer gained all three marks. The candidate correctly states that the SAN begins the depolarisation, that there is a delay at the AVN and that the depolarisation then passes along the bundle of His.

Question 3(b)(i)

This question presented candidates with data from the results of an investigation into the effect of an anti-anxiety drug on the change in heart rate when a student experienced a fright. In this first part of the question candidates had to use the data to calculate the mean volume of blood pumped around the body in one minute, and give the final answer to the nearest whole number. The calculation had several steps – the calculation of the mean heart rate and then using this to determine the total volume of blood to the nearest whole number after converting cm^3 into dm^3. Many candidates completed the calculation correctly to gain both marks. Common errors included not converting between cm^3 and dm^3 correctly and not giving the final answer to the nearest whole number.

(b) Scientists investigated the effect of an anti-anxiety drug on the change in heart rate of a student after a sudden fright.

In this investigation:

- The resting heart rate of the student was measured.
- The student was given a sudden, unexpected fright and their heart rate was measured again.
- This was repeated four more times.
- The investigation was then repeated after the student had taken the anti-anxiety drug.

The table shows the results of this investigation.

Fright number	Heart rate / beats per minute			
	without anti-anxiety drug		with anti-anxiety drug	
	resting	after fright	resting	after fright
1	64	135	46	70
2	56	125	54	65
3	55	125	48	70
4	75	110	56	105
5	72	105	48	65

m = 318 75

(i) The mean volume of blood pumped around the body in one minute after a fright without the anti-anxiety drug is 18 dm^3.

The stroke volume of the student's heart was 150 cm^3. = 0.15

Calculate the mean volume of blood pumped around the body in one minute after a fright, when taking the anti-anxiety drug.

Give your answer in dm^3 and to the **nearest whole number**.

(2)

$75 \times \overset{0.15}{150} = 11.25$

Answer 11 dm^3

ResultsPlus
Examiner Comments

This answer gained both marks – the candidate has correctly calculated the mean and used this to determine the volume.

(b) Scientists investigated the effect of an anti-anxiety drug on the change in heart rate of a student after a sudden fright.

In this investigation:

- The resting heart rate of the student was measured.
- The student was given a sudden, unexpected fright and their heart rate was measured again.
- This was repeated four more times.
- The investigation was then repeated after the student had taken the anti-anxiety drug.

The table shows the results of this investigation.

Fright number	Heart rate / beats per minute			
	without anti-anxiety drug		with anti-anxiety drug	
	resting	after fright	resting	after fright
1	64	135	46	70
2	56	125	54	65
3	55	125	48	70
4	75	110	56	105
5	72	105	48	65

(i) The mean volume of blood pumped around the body in one minute after a fright without the anti-anxiety drug is 18 dm^3. → cardiac output

The stroke volume of the student's heart was 150 cm^3.

Calculate the mean volume of blood pumped around the body in one minute after a fright, when taking the anti-anxiety drug.

Give your answer in dm^3 and to the **nearest whole number**.

(2)

$\frac{70+65+70+105+65}{5} = 75$ bpm or 10 without ? 105

$75 \times 150 = 11250\ cm^3\ min^{-1}$

$\div 10^3$

11.25

Answer 11 dm^3



This answer gained both marks. The candidate also shows all their working – this is an example of good practice.



Always show all your working.

(b) Scientists investigated the effect of an anti-anxiety drug on the change in heart rate of a student after a sudden fright.

In this investigation:

- The resting heart rate of the student was measured.
- The student was given a sudden, unexpected fright and their heart rate was measured again.
- This was repeated four more times.
- The investigation was then repeated after the student had taken the anti-anxiety drug.

The table shows the results of this investigation.

Fright number	Heart rate / beats per minute			
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2	56	125	54	65
3	55	125	48	70
4	75	110	56	105
5	72	105	48	65
		120		75

(i) The mean volume of blood pumped around the body in one minute after a fright without the anti-anxiety drug is 18 dm^3.

The stroke volume of the student's heart was 150 cm^3.

Calculate the mean volume of blood pumped around the body in one minute after a fright, when taking the anti-anxiety drug.

Give your answer in dm^3 and to the **nearest whole number**.

(2)

$\frac{70+65+70+105+65}{5}$ $\times 150$ $\frac{}{1000}$

Answer 11.25 dm^3

ResultsPlus
Examiner Comments

This answer gained one mark. The candidate has completed most of the calculation correctly but not given their final answer to the nearest whole number.

Question 3(b)(ii)

Many candidates gained at least one mark for this question but few went on to gain all four. The candidates were asked to analyse the data to comment on the results of the investigation into the effects of an anti-anxiety drug. Strong candidates explored all the data patterns and often gained credit for: stating that the heart rates before and after were lower with the drug, that the increase in heart rate was less when taking the drug, and that the drug would bind to noradrenaline receptors, preventing the binding of noradrenaline. A few candidates identified the anomalous value and / or recognised that the increase in heart rate after a fright without the drug decreased with more trials. Candidates should take care to describe data patterns carefully – many incorrectly stated that there was a fall in heart rate after a fright when taking the drug, suggesting that the heart rate was slower after the fright (they should have stated that the increase was less when taking the drug).

(ii) The anti-anxiety drug has a similar shape to noradrenaline.

Analyse the data to comment on the results of this investigation.

(4)

If it has a similar shape to the neurotransmitter ~~noradrenaline~~ noradrenaline then it could inhibit the stimulatory response in the sympathetic nervous system. The anti-anxiety drug can bind with noradrenaline receptors in the post synaptic neurone which ~~means~~ means they won't be able to accept noradrenaline produced by an electrical impulse. If there is no neuroreceptor then no action potential is generated and therefore the heart is not stimulated to beat more. The medulla oblongata is unable to stimulate the increase in heart rate.

ResultsPlus
Examiner Comments

This answer gained one mark for the idea of the drug binding with the receptor. The candidate has not described any data pattern.

ResultsPlus
Examiner Tip

When asked to 'comment on' data, candidates should describe all patterns and then give some reasons.

describe explain

(iii) The anti-anxiety drug has a similar shape to noradrenaline.

Analyse the data to comment on the results of this investigation.

(4)

- the heart rate of the student when resting is higher to their resting rate when they did not take the anti-anxiety drug in comparison, when they did take the anti-anxiety drug.
- the heart rate of the student after fright is much larger without taking the anti-anxiety drug than the heart rate after fright when they took the anti-anxiety drug.
- there is a larger difference between the heart rate during resting and after fright when they did not take the drug than when they did
- this could be because the drug which has similar shape to noradrenaline binds to noradrenaline receptors that are on the membrane of our post synaptic neurone
- this causes the cardiac control centre of the medulla oblongata to send impulses to the sympathetic nerve.
- this causes heart rate to increase

(Total for Question 3 = 10 marks)

ResultsPlus
Examiner Comments

This answer gained three marks for the idea that the heart rate was slower when taking the drug (both before and after) compared with without the drug, that the increase in heart rate with the drug was less and that the drug binds to the receptors.

(ii) The anti-anxiety drug has a similar shape to noradrenaline.

Analyse the data to comment on the results of this investigation.

(4)

~~The drug [illegible] seemed to prevent the heart rate from increasing as much as [illegible]~~ Heart rate increased more without drug than with. However with drug it still increased to 105 on one occasion*. The ~~resting~~ resting heart rate was lower with drug before light.

The conclusions drawn from results can't be very reliable - only sampling effects on one person. How is might type controlled

Similar shape to noradrenaline - likely bind to noradrenaline receptors to ~~prevent~~ reduce increase of heart rate

* which is the same as the lowest value without drug after light.

(Total for Question 3 = 10 marks)

ResultsPlus
Examiner Comments

This answer gained three marks for correctly stating that the drug binds to the receptors, the heart rate increases more without the drug, and the resting heart rate is lower with the drug.

(ii) The anti-anxiety drug has a similar shape to noradrenaline.

Analyse the data to comment on the results of this investigation.

(4)

. With the anti-anxiety drug, the resting heart rate and the heart rate after fright are lower than without, and the increase between rest and fright is lower,

. Except on fright number 4, where the increase with the drug was bigger than without

. This is because the anti-anxiety drug can bind to cellular receptors in place of noradrenaline, which stops heart rate from increasing as much

. Because noradrenaline is involved in the sympathetic nervous system, which increases heart rate

. Therefore the sympathetic nervous system will be triggered less after fright (with the anti-anxiety drug) causing a smaller increase in HR.

ResultsPlus
Examiner Comments

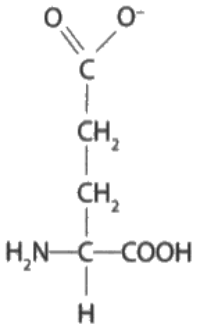
This excellent, detailed answer gained all four marks. The candidate correctly states that the heart rate is lower with the drug, the increase is less, identifies the anomalous point and states that drug binds to the receptors.

Question 4(a)(iii)

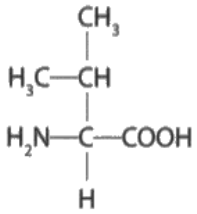
This question focused on the point mutation in sickle cell anaemia. Candidates were shown pictures of glutamate and valine and asked to explain why the change in amino acid would cause the sickle cell haemoglobin molecules to bind together. Many candidates were able to correctly state that glutamate is charged or polar and valine is not charged or non-polar. Fewer went on to give an explanation as to why having an uncharged amino acid would lead to the molecules binding. Some correctly stated that valine would be hydrophobic and some correctly stated that valine would not associate with water molecules and so haemoglobin molecules would bind together to exclude water.

(iii) **Glutamate is a charged, polar amino acid. It is located on the outer surface of unaffected haemoglobin molecules.**

The diagram shows the structure of the amino acids glutamate and valine.



glutamate



valine

Explain why the mutation in sickle cell anaemia causes haemoglobin molecules to bind together.

(2)

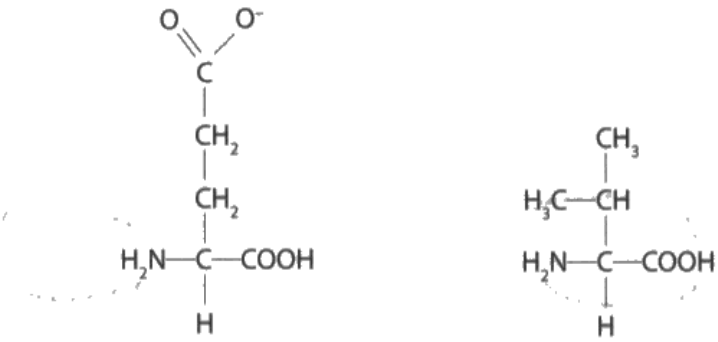
Haemoglobin is a globular protein (hydrophobic amino acids in the centre, hydrophilic on outside). This change in the ~~base~~ sequence of amino acids can change the secondary, tertiary and Quaternary structure of the Protein. leading to non polar amino acids (valine) on the outside of the protein. Hydrophobic amino acids tend to associate and therefore it leads to the haemoglobin molecules sticking together.

ResultsPlus
Examiner Comments

This strong answer gained both marks. The candidate explains that valine is non-polar and explains that it would be hydrophobic and that hydrophobin amino acids often associate together.

(iii) Glutamate is a charged, polar amino acid. It is located on the outer surface of unaffected haemoglobin molecules.

The diagram shows the structure of the amino acids glutamate and valine.



glutamate **valine**

Explain why the mutation in sickle cell anaemia causes haemoglobin molecules to bind together.

(2)

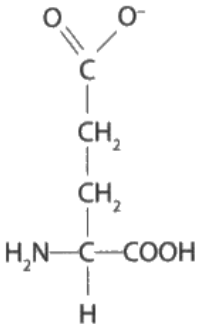
Valine is non-polar ~~and doesn't have~~ When positioned on the outer surface of haemoglobin molecules it causes them to stick together as ~~its~~ it is hydrophobic.

ResultsPlus
Examiner Comments

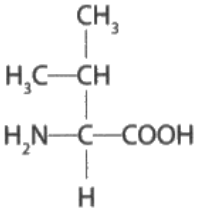
This answer gained both marks for stating that valine is non-polar and is hydrophobic.

(iii) Glutamate is a charged, polar amino acid. It is located on the outer surface of unaffected haemoglobin molecules.

The diagram shows the structure of the amino acids glutamate and valine.



glutamate



valine

Explain why the mutation in sickle cell anaemia causes haemoglobin molecules to bind together.

(2)

- Valine replaced instead of glutamate
- Valine is not charged / not polar
- Valine will be on the surface of affected haemoglobin molecules
- Valine is hydrophobic

ResultsPlus
Examiner Comments

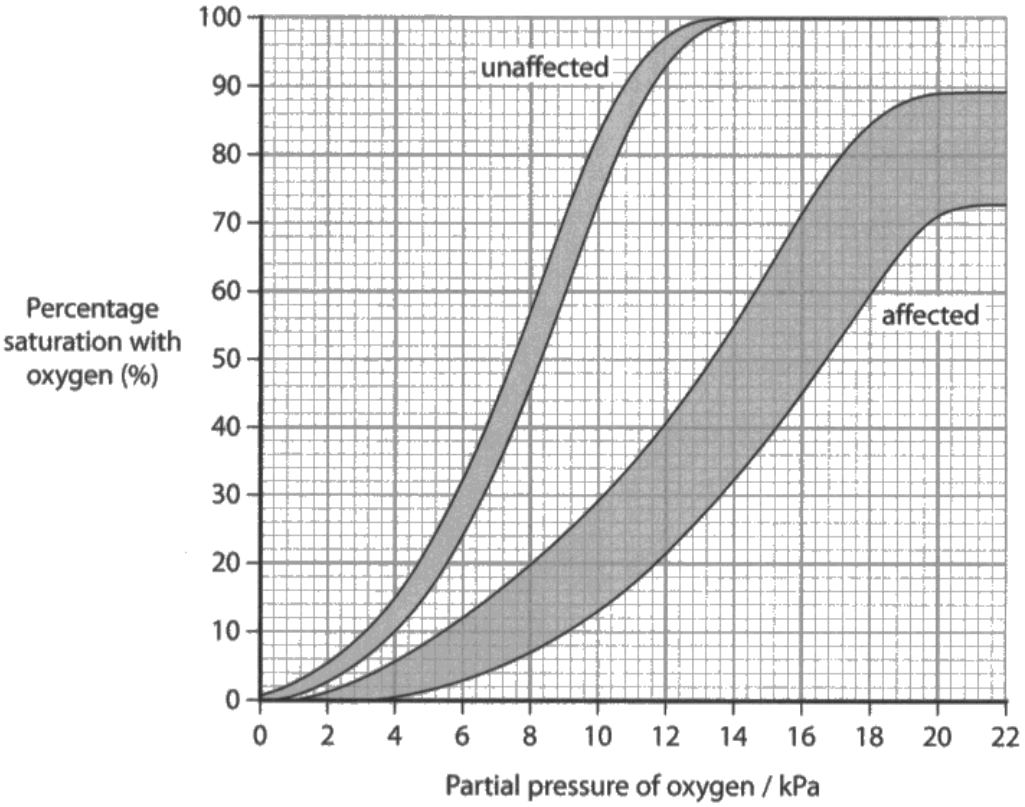
This answer gained one mark for correctly stating that valine is non-polar. No further explanation is given.

Question 4(b)(i)

This question presented candidates with the oxygen dissociation curves for sickle cell anaemia haemoglobin and unaffected haemoglobin. In the first part of the question candidates were asked to compare and contrast the properties of the two types of haemoglobin. Many candidates gained at least one mark, although many gave either only similarities or differences – to gain full marks on this style of question candidates need to give both similarities and differences. Common correct answers were the idea that both had sigmoidal curves, both show cooperative binding, and that the affinity of sickle cell haemoglobin for oxygen is lower.

(b) The graph shows the range of oxygen dissociation curves for haemoglobin taken from people who do not have sickle cell anaemia (unaffected) and from people with sickle cell anaemia (affected).

The shaded areas represent the ranges for each blood sample.



(i) Compare and contrast the properties of haemoglobin from these two groups of people.

(2)

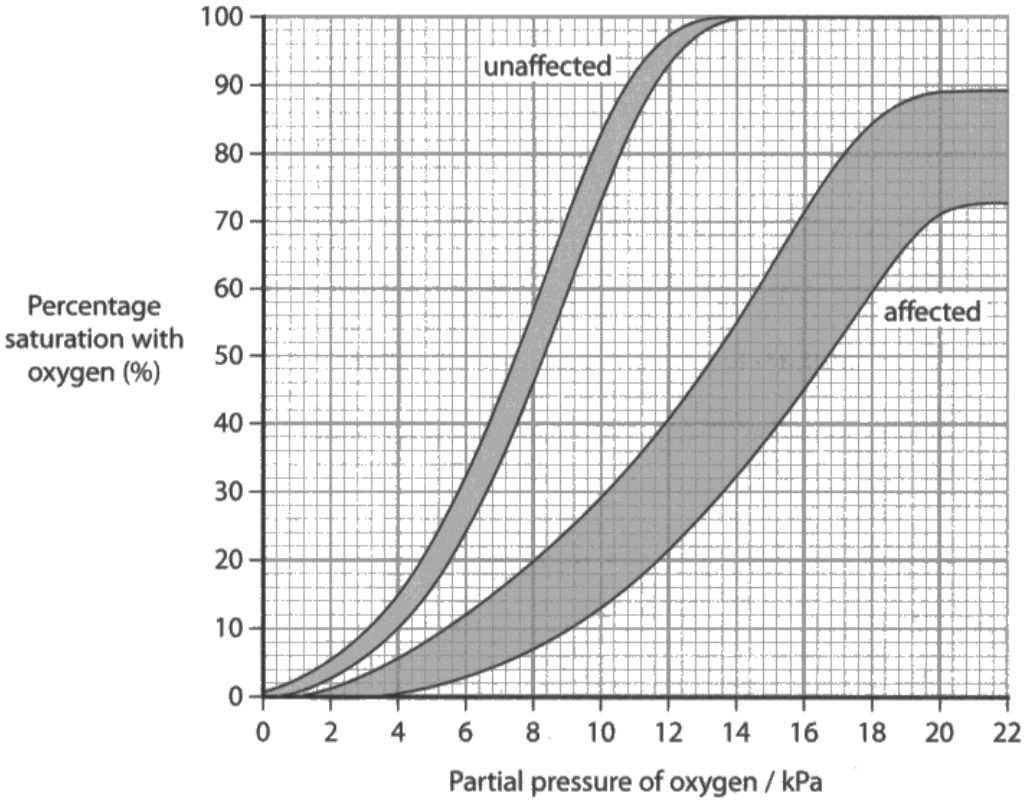
Haemoglobin which has a
people who are affected have lower affinity for O_2 and
Haemoglobin doesn't reach 100% oxygen saturation, when pO_2
partial increases, both Haemoglobin binds to more O_2

ResultsPlus
Examiner Comments

This answer gained one mark for the idea that the sickle cell haemoglobin has a lower affinity.

(b) The graph shows the range of oxygen dissociation curves for haemoglobin taken from people who do not have sickle cell anaemia (unaffected) and from people with sickle cell anaemia (affected).

The shaded areas represent the ranges for each blood sample.



(i) Compare and contrast the properties of haemoglobin from these two groups of people.

(2)

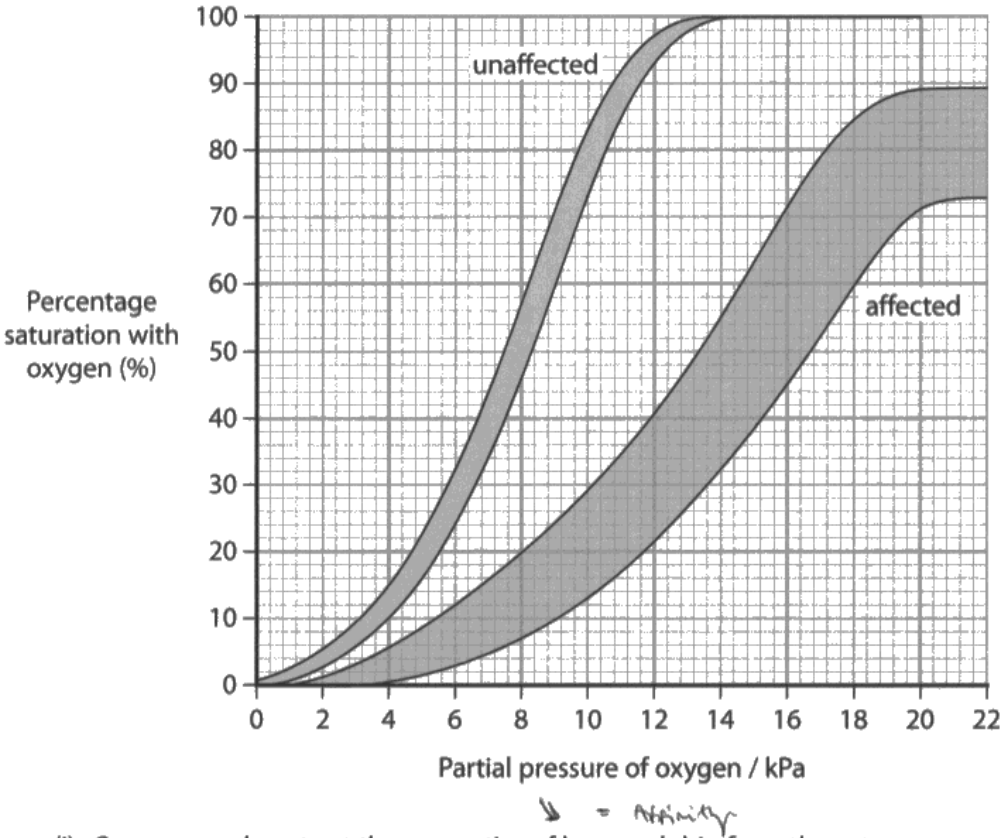
- Both have a Sigmoid shape due to cooperative binding.
- The unaffected group has a smaller range than the affected group which has a larger range.
- Unaffected group plateaus at 100 % but affected group plateaus at 89 %.

ResultsPlus
Examiner Comments

This answer gained both the marks. The candidate gives a correct similarity (the sigmoidal curves) and a difference (the lower plateau for sickle cell haemoglobin).

(b) The graph shows the range of oxygen dissociation curves for haemoglobin taken from people who do not have sickle cell anaemia (unaffected) and from people with sickle cell anaemia (affected).

The shaded areas represent the ranges for each blood sample.



↘ = Affinity

(i) Compare and contrast the properties of haemoglobin from these two groups of people.

(2)

• People without sickle cell anemia have a higher haemoglobin affinity for O_2, as seen by the steep curve.

• However, people with sickle cell anemia have a lower haemoglobin affinity for oxygen,

• This means that unaffected individuals are able to take up O_2 quicker than individuals affected.

ResultsPlus
Examiner Comments

This answer gained one mark for the idea that the haemoglobin from people without sickle cell anaemia has a lower oxygen affinity.

Question 4(b)(ii)

This question assessed candidates understanding of variation. Candidates were asked how the data showed evidence for the fact that there are several genes that affect the phenotype of sickle cell anaemia. Many candidates correctly stated that the range of data was high for sickle cell haemoglobin compared with the unaffected haemoglobin. A few candidates incorrectly referred to the lower saturation of the sickle cell haemoglobin and / or the affinity.

(ii) There is only one known allele that causes sickle cell anaemia.

State how the graph suggests that other genes affect the phenotype of people affected by sickle cell anaemia.

(1)

• The affected individuals Hb doesn't reach full O_2 saturation so genes involved in regulating Hb levels could be affected too

ResultsPlus
Examiner Comments

This answer did not gain the mark as the candidate has incorrectly referred to the oxygen saturation rather than the high range.

(ii) There is only one known allele that causes sickle cell anaemia.

State how the graph suggests that other genes affect the phenotype of people affected by sickle cell anaemia.

haemoglobins (1)

Affected group has a large range in y axis/Hb for oxygen

ResultsPlus
Examiner Comments

This answer gained one mark for correctly stating that the range for sickle cell haemoglobin is high.

Question 4(b)(iii)

This question assessed candidates' understanding of how having a haemoglobin with an oxygen dissociation curve shifted to the right would affect exercise. Many candidates gained at least one mark with a significant number going on to gain all three. Most candidates appreciated that having the curve shifted to the right lowers the affinity of haemoglobin for oxygen. Many went on to state that the oxygen dissociation curve showed that the haemoglobin never becomes fully saturated so that less oxygen would be transported to the muscles for respiration. Fewer candidates went on to give a consequence of the lower aerobic respiration rate such as less ATP for muscle contraction and / or increases accumulation of lactic acid. When discussing muscle activity, candidates should refer to the contraction of the muscles.

(iii) Explain why the oxygen dissociation curve for people with sickle cell anaemia means that they have difficulty exercising.

(3)

The oxygen dissociation curve shows that their haemoglobin has a lower affinity for oxygen and so a lower concentration of oxygen can be delivered by their red blood cells to respiring cells, meaning that the rate of aerobic respiration is limited compared to those without sickle cell anaemia. Therefore they will have to do more anaerobic respiration during exercise than aerobic respiration and this means they will fatigue faster and be more likely to joint due to lack of oxygen and increase in lactic acid production making exercise difficult.

ResultsPlus
Examiner Comments

This answer gained all three marks. The candidate states that the affinity for oxygen is lower, that less oxygen is transported, the respiration rate is lower and that lactic acid will accumulate.

ResultsPlus
Examiner Tip

Always mention muscle contraction when referring to muscle activity.

(iii) Explain why the oxygen dissociation curve for people with sickle cell anaemia means that they have difficulty exercising.

(3)

- affected haemoglobin has lower affinity to oxygen.
- % saturation is lower than normal (under high partial pressure)
- so it binds to ~~fewer of~~ fewer oxygen molecules and delivers less oxygen to body tissues for respiration, so respiration rate decreases, rate of ATP production decreases.
- less energy is supplied to body tissues for muscle contraction
- so they run out of oxygen and energy more easily / quickly.

ResultsPlus
Examiner Comments

This excellent answer gained all three marks. The candidate states that the affinity is lower, less oxygen is carried so that there is less respiration in the muscles and less contraction.

(iii) Explain why the oxygen dissociation curve for people with sickle cell anaemia means that they have difficulty exercising.

(3)

- lower percentage saturation of haemoglobin at a given partial pressure with sickle cell anaemia
- less oxygen can be carried by RBCs and transported to cells
  ↳ Reduced oxygen to act as terminal electron acceptor of ETC during respiration
  ↳ less ATP produced from aerobic respiration for muscle contraction during exercise
- anaerobic respiration may begin, producing lactic acid that causes muscle cramps

(Total for Question 4 = 10 marks)

ResultsPlus
Examiner Comments

This strong answer gained three marks. The candidate clearly states that there is a lower percentage saturation of haemoglobin, reduced oxygen for respiration and less ATP for muscle contraction.

(iii) Explain why the oxygen dissociation curve for people with sickle cell anaemia means that they have difficulty exercising.

(3)

~~Lower affinity for oxygen, so harder for~~

- Haemoglobin less saturated with oxygen at lower partial pressures, so less oxygen to working muscles ⇒ more anaerobic respiration

ResultsPlus
Examiner Comments

This answer gained two marks for the idea of lower oxygen saturation and increased anaerobic respiration in the muscles.

Question 5(b)(i)

This question focused on the effect of auxin on root growth and increase in plant biomass. In this first part of the question, candidates had to extract data from the graph and use it to calculate a percentage increase. Most candidates gained the mark. A small number of candidates read the graph incorrectly and others were unclear how to calculate a percentage change, often dividing by the wrong number.

(i) Calculate the percentage increase in mean root length when given an auxin concentration of 10^{-4} μmol dm^{-3} compared with no auxin.

Give your answer to the **nearest whole number**.

(1)

$\frac{1.3 - 0.7}{0.7} \times 100 = 85.7\%$

Answer 86%

ResultsPlus
Examiner Comments

This is an example of a correct calculation. The candidate has read the graph correctly, and divided by the correct number.

(i) Calculate the percentage increase in mean root length when given an auxin concentration of 10^{-4} μmol dm^{-3} compared with no auxin.

Give your answer to the **nearest whole number.**

(1)

1.3
10^{-4}

1.7
no auxin

$\frac{1.7-1.3}{1.3} \times 100$

Answer 31%

ResultsPlus
Examiner Comments

This answer is incorrect. The candidate has derived the correct numbers from the graph but divided by the wrong number.

Question 5(b)(ii)

This question presented candidates data showing the effect of increasing concentrations of auxin on the root length and growth of wheat seedlings. Most candidates gained at least one mark but few went on to gain all four. Many correctly described the increase and decrease of both root length and plant mass but very few stated that there was a positive correlation between root length and seedling growth. Candidates should always look for correlations between data series and state whether they are positive or negative. Few went on to suggest explanations for the growth of the roots. The strongest answers explained that longer roots would have a larger surface area and so be able to uptake more mineral ions and water. Some candidates then went on to give functions for mineral ions that would affect growth, such as calcium for calcium pectate production in the cell walls. Few candidates referred to the error bars shown on the first graph – if error bars are present on a graph, candidates should make reference to them discussing the significance of the size of the error bars and the presence or absence of overlaps.

(ii) Analyse the data to discuss the effects of auxin on the growth of wheat seedlings.

(4)

until a concentration of around $10^{-2.5}$ μmol dm^3 increasing auxin concentration causes more growth in the roots, which increases the plants biomass as there is more surface area in the roots for active transport of nutrients such as nitrate ions for protein synthesis. past the $10^{-2.5}$ μmol dm^3 concentration, ~~the~~ the auxin becomes inhibitory and growth of roots is reduced, meaning less active transport of nutrients and mineral ions can occur, so the seedling grows less overall.

ResultsPlus
Examiner Comments

This is a strong answer that gained three marks. The candidate describes the pattern and then goes on to discuss the effect of nitrate ion uptake on protein synthesis.

(ii) Analyse the data to discuss the effects of auxin on the growth of wheat seedlings.

(4)

As the concentration of auxin increases to 10^{-3} µmol dm^{-3}, the mean root length increases. The error bars cross between 10^{-4} and around 10^{-3} meaning there is no significant difference. This increase in mean root length means more minerals are able to be absorbed from the soil such as nitrates for the production of amino acids. This increases the growth of wheat seedling and therefore the ~~biomass~~ mean dry biomass ass the cells are able to elongate. This is due to the pumping of hydrogen ions which weakens hydrogen bonds allowing water to enter via osmosis. After 10^{-5} concentration, the mean root length decreases as too many H^+ ions are pumped in denaturing the enzymes and decreasing growth and therefore mean dry biomass.

(Total for Question 5 = 6 marks)

ResultsPlus
Examiner Comments

This is an excellent answer that gained all four marks. The candidate describes the pattern of growth, the significance of the error bars, and then discusses the role of nitrate ions in amino acid synthesis.

(ii) Analyse the data to discuss the effects of auxin on the growth of wheat seedlings.

(4)

As concentration increases, mean root length increases until 10^{-1} mmol dm^{-3} when it decreases to 0.2cm, lower than without auxin, because auxin in high concentrations inhibits root growth. ~~This is~~ As concentration increases, mean dry biomass increases until 10^{-3} mmol dm^{-3} when it decreases down to 1.2mg, this is because there's less root growth so fewer ions can be taken up e.g. nitrates which are needed to make DNA, RNA and amino acids to make protein for growth.

ResultsPlus
Examiner Comments

This is a strong answer that gained three marks. The candidate describes the growth patterns, and the effect on nitrate ions on the production of named organic molecules.

(ii) Analyse the data to discuss the effects of auxin on the growth of wheat seedlings.

(4)

Mean root length increases as auxin concentration increases until $10^{-2.9}$, and decreases when auxin increases further. Mean dry biomass increases until $10^{-3.1}$, and decreases when auxin increases further. as auxin goes up

Auxin stimulates the elongation of cells on the shaded region so the ~~root~~ ~~apex of~~ the root can point towards the light for more photosynthesis. However, too much auxin can ~~be~~ lead to a root that is bent too much on one side so it cannot adjust to the direction of light when it varys.

ResultsPlus
Examiner Comments

This answer gained one mark for describing the effect of auxin. No explanations or discussion of the error bars are given.

Question 6(a)(ii)

This straightforward question asked candidates to give one type of evidence that scientists can use to determine evolutionary relationships. Most candidates gained the mark. Common, correct answers included the uses of DNA sequencing, gel electrophoresis, bioinformatics, and morphology.

(ii) State **one** method that scientists use to determine the evolutionary relationships of the brown rat compared with other species.

(1)

DNA sequencing.

ResultsPlus
Examiner Comments

This is an example of a common, correct answer – DNA sequencing.

(ii) State **one** method that scientists use to determine the evolutionary relationships of the brown rat compared with other species.

(1)

use of ~~gene~~ DNA profiling / gel electrophoresis to establish similar / common DNA in 2 organisms inferring a common ancestor

ResultsPlus
Examiner Comments

This is an example of a commonly seen, correct answer – gel electrophoresis.

(ii) State **one** method that scientists use to determine the evolutionary relationships of the brown rat compared with other species.

(1)

Molecular phylogeny; studying and analysing genetic material



This answer gained the mark for stating that molecular phylogenics could be used.

Question 6(b)(i)

This question assessed candidates' ability to use the Hardy-Weinberg formula to determine the number of heterozygous individuals in a population. The examiners were impressed with the large number of candidates who were able to correctly calculate the number of heterozygous rats and gain all three marks. It is clear that many candidates and centres practise Hardy-Weinberg calculations carefully and so have a good, solid understanding of how to complete them. A number of candidates did not attempt the question – Hardy-Weinberg calculations are a part of Topic 8 and candidates should spend time working out how to complete them.

(b) Warfarin is a poison that is often used to control brown rat populations.

In areas where large amounts of warfarin have been used, many rats have developed resistance to warfarin.

Three genotypes occur in rat populations:

W^NW^N – rats that are not resistant to warfarin

W^RW^R – rats that are resistant to warfarin but require large amounts of vitamin K in their diet to survive

W^NW^R – rats that are resistant to warfarin and **do not** require large amounts of vitamin K to survive.

After the introduction of warfarin, scientists determined the change in numbers of rats that were resistant to warfarin, and the number that were not resistant to warfarin.

The table shows their results.

Type of rat	Genotypes of rats	Number of rats		
		before warfarin was used	two years after warfarin use started	five years after warfarin use started
Resistant to warfarin	W^RW^R and W^NW^R	35	195	180
Not resistant to warfarin	W^NW^N	265	105	120

(i) Calculate the expected number of rats that would be resistant to warfarin but **do not** require large amounts of vitamin K to survive, before warfarin was used.

Use the Hardy-Weinberg equation

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

$q^2 = 0.883$

$q = 0.9$

$q^2 = 265$ ~~$\sqrt{265}$ 16.3~~

$q = 0.94$

$p = 0.06$

$p = 0.1$

$2 \times 0.94 \times 0.06 = 0.1128 \times 300 = 34$

$2 \times 0.9 \times 0.1 = 0.18 \times 300 = 54$

265/300

$= 0.883$

$9\sqrt{0.883}$

(3)

Answer 54

ResultsPlus
Examiner Comments

This answer gained two marks. The candidate correctly calculated values for p and q, also derived the correct answer but replaced this answer with an incorrect one.

(b) Warfarin is a poison that is often used to control brown rat populations.

In areas where large amounts of warfarin have been used, many rats have developed resistance to warfarin.

Three genotypes occur in rat populations:

W^NW^N – rats that are not resistant to warfarin

W^RW^R – rats that are resistant to warfarin but require large amounts of vitamin K in their diet to survive

W^NW^R – rats that are resistant to warfarin and **do not** require large amounts of vitamin K to survive.

After the introduction of warfarin, scientists determined the change in numbers of rats that were resistant to warfarin, and the number that were not resistant to warfarin.

The table shows their results.

Type of rat	Genotypes of rats	Number of rats		
		before warfarin was used	two years after warfarin use started	five years after warfarin use started
Resistant to warfarin	W^RW^R and W^NW^R	35	195	180
Not resistant to warfarin	W^NW^N	265	105	120

(i) Calculate the expected number of rats that would be resistant to warfarin but **do not** require large amounts of vitamin K to survive, before warfarin was used.

Use the Hardy-Weinberg equation

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

(3)

$q^2 = W^N W^N$

$W^N W^N = \frac{265}{300}$

$q = \sqrt{\frac{265}{300}}$

$p + q = 1$

$p + \sqrt{\frac{265}{300}} = 1$

$p = 1 - \sqrt{\frac{265}{300}}$

$p = \frac{30 - \sqrt{795}}{30}$

$p^2 = 3.617 \times 10^{-3}$

$q^2 = \frac{265}{300}$

$(1 - 3.617 \times 10^{-3} - \frac{265}{300}) = 2pq$

$2pq = 0.11305$

$2pq \times 300 = 34$

Answer 34

ResultsPlus
Examiner Comments

This answer gained all three marks. The candidate has shown all their working and it is clear how they reach the answer.

ResultsPlus
Examiner Tip

When completing Hardy-Weinberg calculations to determine the number of heterozygotes:

1. Find the frequency of individuals with a recessive phenotype (q^2).
2. Use the value of q^2 to find the frequence of the recessive allele (q).
3. Use the formula, p+q=1 to find the frequency of the dominant allele (p).
4. Use the formula 2pq to find the frequency of heterozygotes.
5. Use the frequency of heterozygotes to find the total number of heterozygous individuals in the population.

(b) Warfarin is a poison that is often used to control brown rat populations.

In areas where large amounts of warfarin have been used, many rats have developed resistance to warfarin.

Three genotypes occur in rat populations:

W^NW^N – rats that are not resistant to warfarin

W^RW^R – rats that are resistant to warfarin but require large amounts of vitamin K in their diet to survive

W^NW^R – rats that are resistant to warfarin and **do not** require large amounts of vitamin K to survive.

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(i) Calculate the expected number of rats that would be resistant to warfarin but **do not** require large amounts of vitamin K to survive, before warfarin was used.

Use the Hardy-Weinberg equation

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

(3)

$q^2 = \frac{35+265}{300}$ $\quad 2pq$ $\quad 0.94 \times 2 \times (1-0.94)$

$q = 0.94$ $\quad 2 \times 0.94 \times (1-0.94) = 0.11$

$0.11 \times 300 = 33.914$

$2pq$ $\quad 2 \times \sqrt{\frac{35}{300}} \times (1-\sqrt{\frac{35}{300}}) = 0.4644$

$0.4644 \times 300 = 139.47$

Answer 34



This is an example of a correct answer that gained all three marks.



When you have completed your calculation, make sure that the frequency of homozygous dominant (p^2), heterozygotes (2pq) and homozygous recessive (q^2) add up to 1.

Question 6(b)(ii)

This question was well answered with most candidates gaining at least one mark and many going on to gain both. Candidates had to explain the increase in frequency of the warfarin resistance allele in rats. Most stated that individuals with the allele would survive, breed and pass on the allele. Candidates should be careful to refer to alleles rather than genes when appropriate – the terms, 'different alleles' and 'different genes' have different meanings.

(ii) Explain why, after two years, there is a change in the number of rats that are resistant to warfarin.

(2)

Because rats that are resistant to warfarin have a selective advantage and this gives them a higher chance of surviving under the selection pressure of warfarin. They survive and have a higher chance to reproduce and pass on the advantageous gene leading to increase in resistant to warfarin ~~in~~ after 2 years.

ResultsPlus
Examiner Comments

This answer gained one mark for the idea of survival. The second mark was not awarded as the candidate referred to passing on genes rather than alleles.

ResultsPlus
Examiner Tip

Don't confuse the terms 'allele' and 'gene'.

(ii) Explain why, after two years, there is a change in the number of rats that are resistant to warfarin.

(2)

Worry it The number of rats resistant increases. Warfarin acts as a selection pressure and the ones with the favourable allele (resistant) were able to outcompete, survive and reproduce. Passing the allele to thier offspring, increasing the gene frequency within a population.

ResultsPlus
Examiner Comments

This answer gained both marks for the ideas of survival / reproduction and passing on the allele.

(ii) Explain why, after two years, there is a change in the number of rats that are resistant to warfarin.

(2)

~~the rats are exposed to warfarin & they develop mutations~~ The rats that are resistant to warfarin reproduce and their offspring has the advantageous allele that makes them resistant. The non-resistant rats will ~~eventually~~ not survive the warfarin & their non-advantageous allele won't be passed onto offspring. The coming generations will have a larger number of resistant rats due to the passing on of the advantageous allele.

ResultsPlus
Examiner Comments

This answer gained both marks for the ideas of reproduction and passing on the allele.

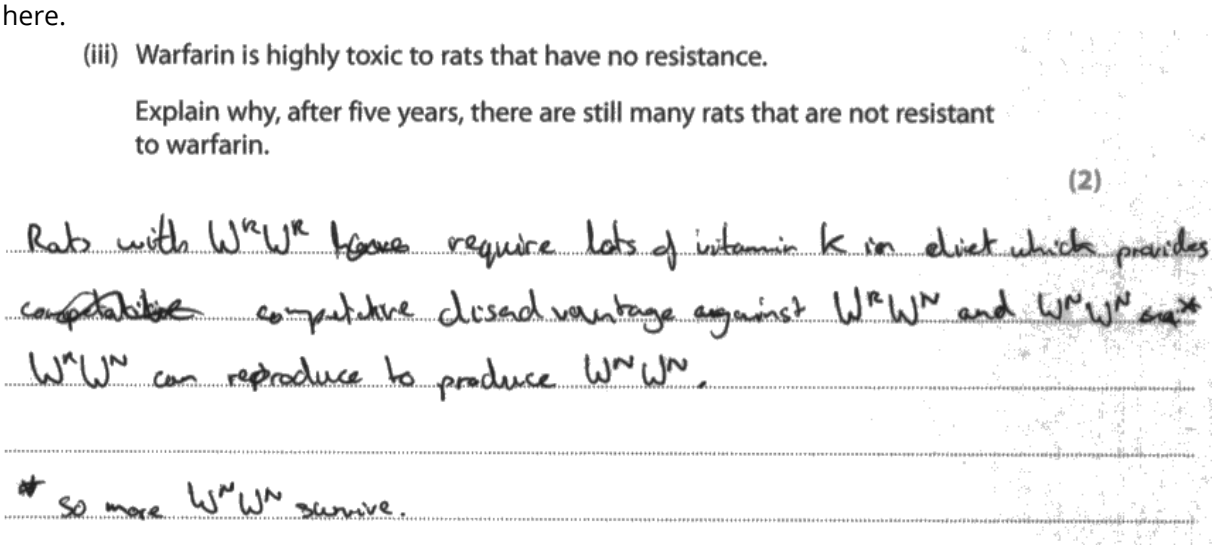
Question 6(b)(iii)

Many candidates found this question challenging. The question asked candidates to explain why some rats that were not resistant to warfarin were still present in the population after five years. The strongest answers recognised that heterozygous rats were at the greatest advantage as they would not require additional vitamin K and would still be resistant to warfarin, whilst those individuals with two resistance alleles would often not survive due to a lack of vitamin K. A number of candidates incorrectly suggested that the rats had learnt to avoid poison and others referred to founder effects and bottlenecks which were not relevant here.

(iii) Warfarin is highly toxic to rats that have no resistance.

Explain why, after five years, there are still many rats that are not resistant to warfarin.

(2)



ResultsPlus
Examiner Comments

This answer gained two marks for the idea that the W^NW^N rats would be at a disadvantage due to needing large amounts of vitamin K and that the W^NW^R rats can still pass on a W^N allele.

(iii) Warfarin is highly toxic to rats that have no resistance.

Explain why, after five years, there are still many rats that are not resistant to warfarin.

(2)

(the rats did not encounter as much warfarin)
· When 2 heterozygous W^NW^R resistant rats reproduce 25% homozygous W^RW^R (resistant but need vit K) 50% W^RW^N resistant and don't require lots of vit K to survive. and 25% non-resistant W^NW^N rats. More heterozygous W^RW^N made as more beneficial (no need to rely on high conc of vit K to survive) so there's still a lot of rats that are not resistant to ~~the~~ warfarin.
Fewer W^RW^R as some rats die due to low vit K, not from the warfarin

(Total for Question 6 = 9 marks)

	W^R	W^N
W^R	W^RW^R	W^RW^N
W^N	W^RW^N	W^NW^N

3:1 → not resistance
↓
resistant

ResultsPlus
Examiner Comments

This excellent answer gained both marks for correctly describing how heterozygous rats have an advantage by not needing extra vitamin K, that they survive and that they can still pass on the W^N allele.

(iii) Warfarin is highly toxic to rats that have no resistance.

Explain why, after five years, there are still many rats that are not resistant to warfarin.

(2)

- The rats that are not resistant to warfarin are isolated from the other population of rats
- As a result of the founder effect, a genetic bottleneck has occurred as the rats are not isolated they are not affected by warfarin, and their number increase is isolated, allowing for the gene to be inherited to offspring

ResultsPlus
Examiner Comments

This is an example of a common incorrect answer that gained no marks. The candidate is incorrectly referring to founder effects.

Question 7(b)(i)

This question asked candidates to determine the direction of water flow between three cells with different water potentials. Many candidates were able to correctly show the direction of water flow. Where candidates did not gain the mark, it was often for incorrectly assuming that -400 kPa was greater than -200 kPa.

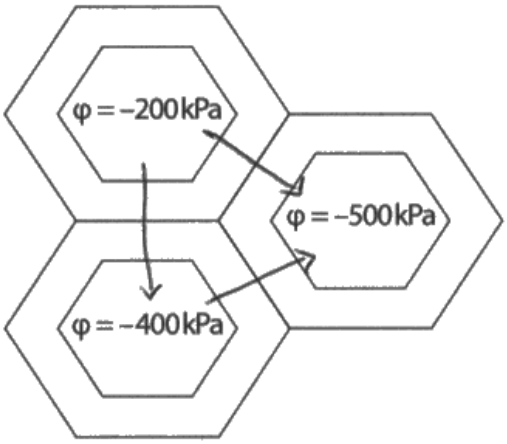
(b) The number of fructose molecules in inulin can vary from 10 to 70.

Inulin with high numbers of fructose molecules is less soluble in water.

(i) The diagram shows three plant cells with different water potentials.

Draw arrows on the diagram to show the direction of water movement between the cells.

(1)



ResultsPlus
Examiner Comments

This answer gained the mark – the candidate has added arrows in the correct directions.

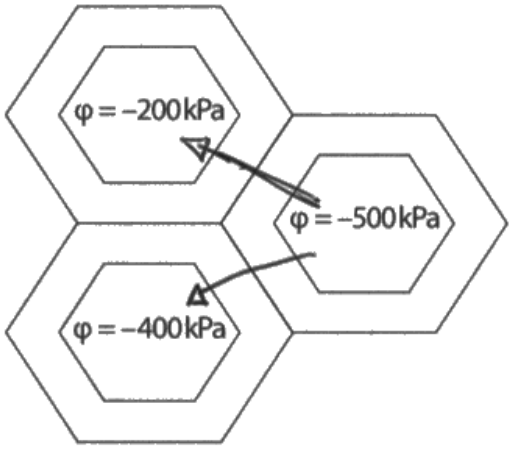
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Inulin with high numbers of fructose molecules is less soluble in water.

(i) The diagram shows three plant cells with different water potentials.

Draw arrows on the diagram to show the direction of water movement between the cells.

(1)



ResultsPlus
Examiner Comments

This answer did not gain the mark. The arrows are pointing in the wrong directions and only two arrows are drawn.

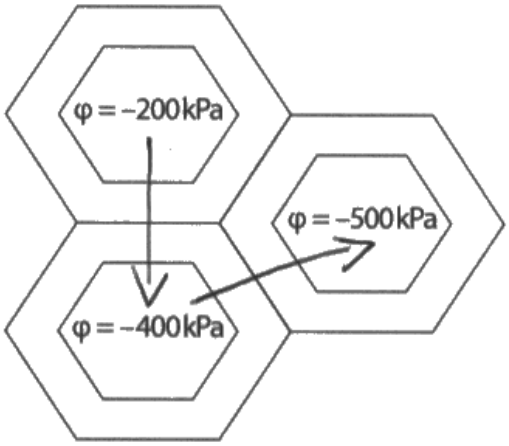
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Inulin with high numbers of fructose molecules is less soluble in water.

(i) The diagram shows three plant cells with different water potentials.

Draw arrows on the diagram to show the direction of water movement between the cells.

(1)



ResultsPlus
Examiner Comments

This answer did not gain the mark. Two arrows point in the correct direction but the candidate has not drawn the third arrow.

Question 7(b)(ii)

This challenging question generated answers with a wide range of quality. Strong answers explained that in dry conditions the inulin would be more soluble, would lower the water potential of cells and so prevent water loss by osmosis or allow the uptake of water. Many candidates gained at least one mark, usually for stating that the inulin would be more soluble in dry conditions, but fewer went on to refer to water uptake by osmosis or the lowering of water potential. If a question is clearly focused on osmosis, candidates should refer to water potentials.

(ii) Explain why some plant species make inulin with fewer fructose molecules in dry weather and inulin with more fructose molecules in wet weather. ↓ water ↑ water

(2)

As in ~~wet~~ dry weather there are less water molecules available in the soil, so they want to have a lower water potential to take in more water in ~~cells~~ so the storage ~~cells~~ molecules need to be more soluble to water to take more water in for photosynthesis so less insoluble fructose molecules used to make inulin. In wet whether where there is more water potential more insoluble fructose so ~~they~~ inulin has a higher water potential to prevent excessive water molecules from ~~entering~~ the cells and lysing them Plant

ResultsPlus
Examiner Comments

This answer gained two marks. The candidate has stated that inulin will be more soluble and that this lowers the water potential.

ResultsPlus
Examiner Tip

Make sure that you refer to water potentials when discussing osmosis.

(ii) Explain why some plant species make inulin with fewer fructose molecules in dry weather and inulin with more fructose molecules in wet weather.

(2)

In dry weather, ~~a~~ some plants make soluble inulin, hence water will be more likely to move into the storage molecule, ~~as~~ via osmosis, hence the plant cell will retain more water in dry weather, as it stores it. The converse is true for wet weather.

ResultsPlus
Examiner Comments

This answer gained two marks. The candidate refers to more soluble inulin and also to the uptake of water by osmosis.

(ii) Explain why some plant species make inulin with fewer fructose molecules in dry weather and inulin with more fructose molecules in wet weather.

(2)

in wet weather high numbers of fructose is more favourable as it is less soluble in water. Therefore has less of an osmotic effect on plant reactions

ResultsPlus
Examiner Comments

This answer gained one mark for inulin being less soluble in wet weather. Osmosis is mentioned by there is no reference to the direction of water flow.

(ii) Explain why some plant species make inulin with fewer fructose molecules in dry weather and inulin with more fructose molecules in wet weather.

(2)

Because in dry weather, plant requires more ~~water~~, therefore ~~fewer~~ fructose molecules will create a lower water potential and water move from higher water potential to lower water potential therefore will have more water come into the plant, same for when weather is wet, plant want water to move out and more

Because in dry weather there are less water in plant so fructose molecules can be soluble in water as there's no water In wet weather higher number of fructose molecules is less soluble in water and as in wet weather plant will have lots of water therefor fructose need to be insoluble.

ResultsPlus
Examiner Comments

This answer gained one mark with the idea that the inulin is less soluble in wet weather.

Question 7(c)(i)

This mathematical question required candidates to use a tangent to the curve to determine the fastest rate and derive the unit correctly. Some candidates determined the mean rate for the whole curve and others selected areas on the curve where it was clearly less steep. Drawing tangents to curves is one of the mathematical skills required at A-Level.

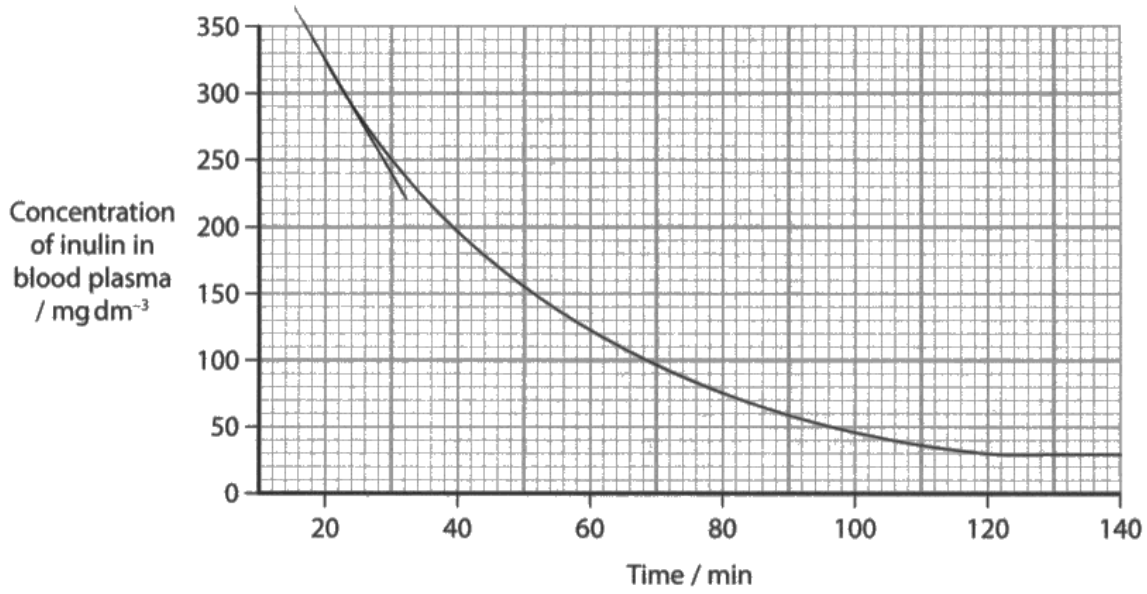
(c) Inulin is used to measure the rate of filtration by the kidneys.

A saline solution containing inulin is injected into the vein of a patient.

The concentration of inulin in the blood plasma is then measured over time.

The rate of filtration is a measure of the maximum rate that inulin is removed from the blood by the kidneys.

The graph shows the concentration of inulin in the blood plasma after an injection of 5 g of inulin.



(i) Calculate the maximum rate that the inulin is removed from the blood.

Give your answer to **two decimal places** with appropriate units.

(2)

(30, 250) (40, 200)

$\frac{250-200}{30-40} = -5$

(20, 325) (24, 290)

$\frac{325-290}{20-24} = 8.75$

8.75 mg dm^{-3} min^{-1}

Answer .....

ResultsPlus
Examiner Comments

This answer gained two marks. The gradient is within tolerance and the unit is correct.

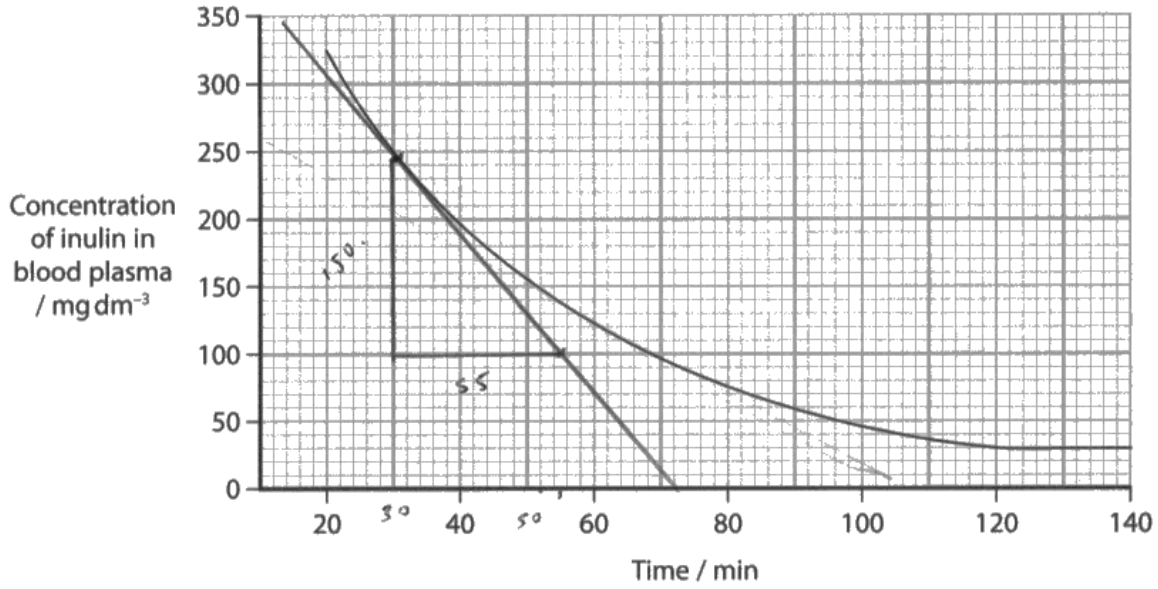
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(i) Calculate the maximum rate that the inulin is removed from the blood.

Give your answer to **two decimal places** with appropriate units.

(2)

$\frac{150}{55} = 2.72$

Answer 2.72.



This answer gained no marks. The tangent to the curve is not at the steepest point and there are no units.



Make sure that you include units if necessary.

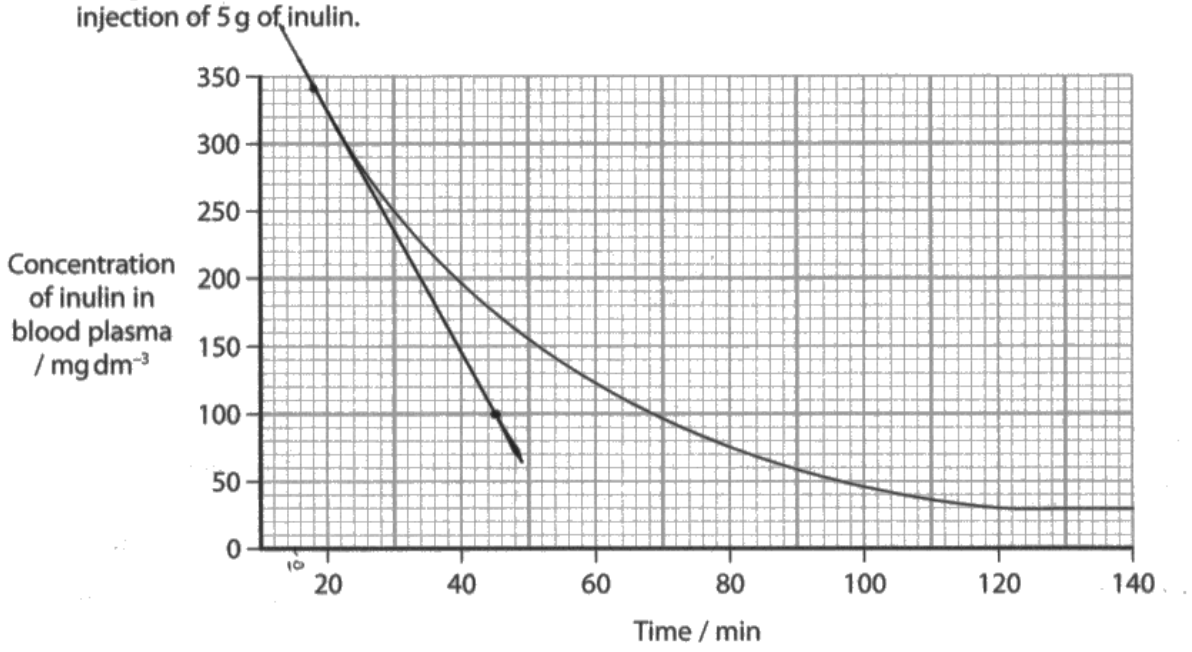
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The graph shows the concentration of inulin in the blood plasma after an injection of 5 g of inulin.



(i) Calculate the maximum rate that the inulin is removed from the blood.

Give your answer to **two decimal places** with appropriate units.

(2)

$\frac{343 - 100}{45 - 16} = 8.3793 = 8.38$

mg dm^{-3} min^{-1}

Answer 8.38 mg dm^{-3} min^{-1}

ResultsPlus
Examiner Comments

This answer gained two marks for a gradient that is in tolerance and correct units.

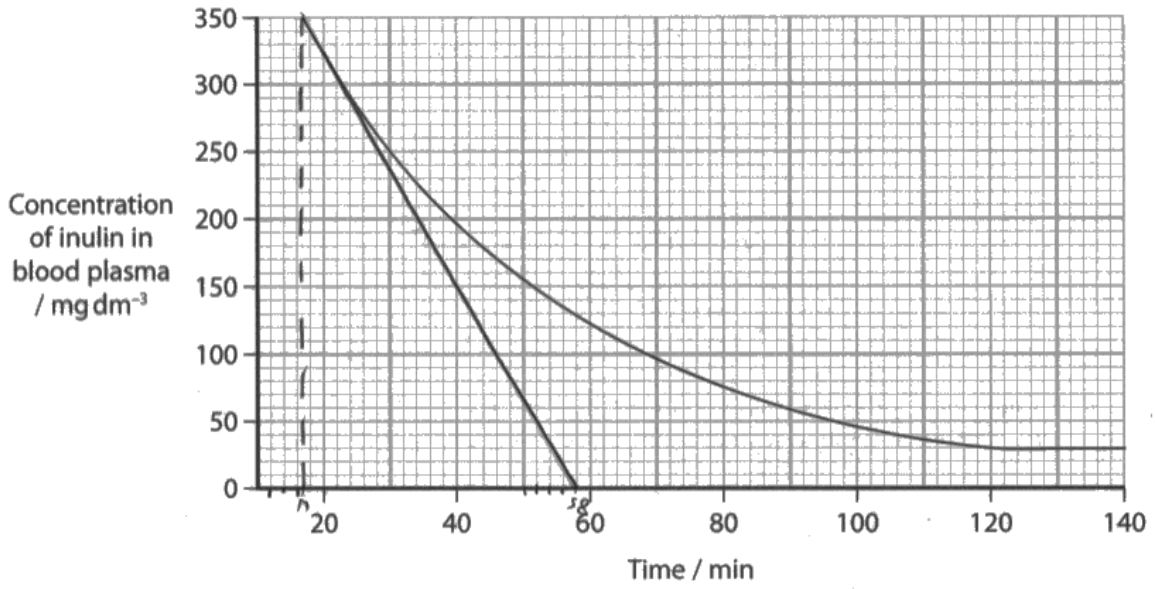
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The graph shows the concentration of inulin in the blood plasma after an injection of 5 g of inulin.



(i) Calculate the maximum rate that the inulin is removed from the blood.

Give your answer to **two decimal places** with appropriate units.

(2)

58 - 17

$\frac{350}{58-17} = 8.54 \text{ mg dm}^{-3} \text{ min}^{-1}$

Answer 8.54 mg dm⁻³ min⁻¹

ResultsPlus
Examiner Comments

This answer also gained two marks as the gradient is within tolerance and the unit is correct.

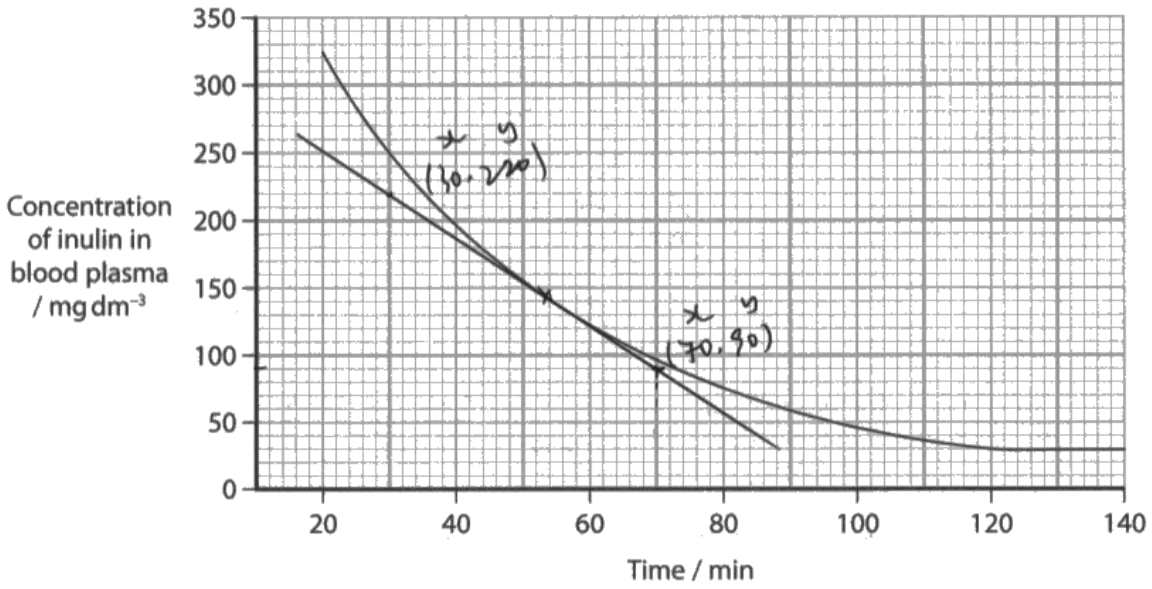
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The graph shows the concentration of inulin in the blood plasma after an injection of 5 g of inulin.



(i) Calculate the maximum rate that the inulin is removed from the blood.

Give your answer to **two decimal places** with appropriate units.

(2)

$\frac{220 - 90}{30 - 70} = -3.25$ mg dm^{-3} min^{-1}

Answer 3.25 mg dm^{-3} min^{-1}

ResultsPlus
Examiner Comments

This answer gained one mark for the unit. The tangent is, however, drawn in the wrong place.

Question 7(c)(ii)

This question assessed candidates' understanding of the process of ultrafiltration in the context of inulin clearance from blood plasma. Strong answers stated that ultrafiltration occurs and that the inulin is forced from the blood in the glomerulus into the Bowman's capsule because it is small enough to pass through the pores in the capillaries or through the basement membrane. Many candidates scored at least one mark but fewer went on to gain both. A significant number did not mention ultrafiltration, and some stated that the inulin leaves the blood but did not explain that its small size enables it to pass through the pores.

(ii) Explain how inulin passes from the blood plasma into the proximal convoluted tubule of a nephron.

(2)

High pressure causes ultrafiltration and smaller molecules to be forced through the glomerelus and into the proximal convilated tubule as filtrate.

ResultsPlus
Examiner Comments

This answer gained one mark for stating that ultrafiltration allows the inulin to leave the blood.

ResultsPlus
Examiner Tip

If discussing ultrafiltration, always refer to sizes of molecules and the sizes of the pores in the membranes.

(ii) Explain how inulin passes from the blood plasma into the proximal convoluted tubule of a nephron.

(2)

• high pressure causes solutes to move out into the bowmans capsule.

• when blood is transported to the proximal convoluted tubule, molecules such as inulin move out of the blood vessels through gaps pores down a concentration gradient.

ResultsPlus
Examiner Comments

This answer did not gain any marks. The candidate has not mentioned the glomerulus and has confused ultrafiltration with diffusion.

(ii) Explain how inulin passes from the blood plasma into the proximal convoluted tubule of a nephron.

(2)

Blood vessel ~~leaving~~ ~~bowman~~ leading into glomerulus is wider than blood vessel leaving glomerulus. This generates high pressure in glomerulus blood vessels that forces inulin molecules out of glomerulus via pores in basement membrane of bowman's capsule into proximal convoluted tubule. The inulin is small enough to fit / pass through pores in basement membrane.

ResultsPlus
Examiner Comments

This strong answer gained two marks. The candidate correctly describes the high pressure filtration, the movement of inulin from glomerulus to Bowman's capsule and explains that

the small size of inulin enables it to pass through the pores.

Question 7(c)(iii)

This answer assessed candidates' understanding of the role of the proximal convoluted tubule in reabsorption of substances. Candidates had to determine that inulin is released into the urine as it is a molecule that has no function in humans and that once released into the filtrate there is no method for the proximal convoluted tubule to reabsorb it. Many answers gained at least one mark and a significant number went on to gain both. Many stated that inulin has no function and many also stated that it is not reabsorbed. Few went on to refer to the lack of channels for inulin in the proximal convoluted tubule.

(iii) Explain why all the inulin is released into the urine.

(2)

~~as~~ insulin is no longer required and so is a waste product; released into urine through the ~~PCT~~ DCT and collected at the bladder.

ResultsPlus
Examiner Comments

This answer gained one mark for the idea that inulin is a waste product. No mention of reabsorption is given so mark point two was not awarded.

(iii) Explain why all the inulin is released into the urine.

(2)

Inulin is not reabsorbed into blood capillary

Inulin along with urea is removed as waste product because

doesnot ~~of~~ contain glucose (instead fructose) or amino acids

ResultsPlus
Examiner Comments

This answer gained two marks for the idea that inulin is a waste substance and that it is not reabsorbed.

(iii) Explain why all the inulin is released into the urine.

(2)

It is not useful or needed by our body as it is for plant storage so it is all filtered out.

ResultsPlus
Examiner Comments

This answer gained one mark for the idea of inulin not being of use. Filtered out is a vague term that should not be awarded.

ResultsPlus
Examiner Tip

Try not to use the phrase 'filtered out' when explaining kidney function, stick to key phrases and terms such as ultrafiltration and reabsorption.

(iii) Explain why all the inulin is released into the urine. becomes the PCT

(2)

- inuline is not reabsorbed by the proximal convoluted tubule as co-transport with carrier proteins of Na+ doesn't occur into the epithelial cells so can't diffuse back into bloodstream
- inulin is not needed in the body as the substance required is glucose to be stored as glycogen
- hormones aren't activated to actively transport inulin in distal convoluted tubule

(Total for Question 7 = 12 marks)

ResultsPlus
Examiner Comments

This is a strong answer that gained both marks. The candidate explains that inulin is not needed, that is not reabsorbed and that there are no channels for it in the proximal convoluted tubule.

Question 8(b)

This question required candidates to complete a Spearman's rank correlation test and interpret the result. The examiners were very impressed with how well many candidates completed Q08(b)(i) and Q08(b)(ii). Many candidates were able to complete the table and go on to calculate the coefficient correctly. Some candidates found calculating an average rank challenging and others forgot to give the final coefficient as a negative number. Many candidates found interpretation of the results of the test challenging. Strong answers identified the correct critical value, and correctly stated that the calculated value was higher than the critical value and so there was a significant negative correlation. When describing the results, candidates should use the term 'significant' and state whether a correlation is positive or negative. A significant number of candidates calculated the value correctly and then incorrectly stated that as the value was negative, it was lower than the critical value.

(b) As heather plants age, the ratio of leaf area to area of woody stem changes.

A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

The student carried out a Spearman's rank correlation test using the data in the table.

Age of heather plant / years	Rank of age of heather plant	Ratio of leaf area : woody stem area	Rank of leaf area : woody stem area	d	d^2
16	4	0.7	4.5	–0.5	0.25
15	5	0.4	8	–3	9
12	6	0.6	6	0	0
4	9	2.0	1	8	64
7	8	1.1	2.5	5.5	30.25
22	1	0.2	10	–9	81
20	2	0.3	9	–7	49
3	10	1.1	2.5	-7.5	56.25
17	3	0.5	7	–4	16
11	7	0.7	4.5	2.5	6.25

(i) Calculate the missing values to complete the table.
Write your answers in the table.

(2)

(ii) Calculate the Spearman's rank correlation coefficient for the data in the table.
Use the formula

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

(3)

$\Sigma d^2 = 312$

$n(n^2-1) = 10(10^2-1)$
$= 990$

$1 - \frac{6(312)}{990} = -0.890$

Answer -0.891

(iii) The table gives some critical values for the Spearman's rank correlation coefficient.

n	Level of significance	
	$P = 0.05$	$P = 0.01$
5	1.000	–
6	0.886	1.000
7	0.786	0.929
8	0.738	0.881
9	0.700	0.833
10	0.648	0.794
11	0.618	0.755

Comment on the relationship between the age of the heather and the ratio of leaf area to woody stem area.

Use your calculated value of Spearman's rank correlation coefficient and the table.

(3)

critical value at 16 degrees of freedom at the 5% significance is 0.648.
0.891 > 0.648 ∴ a reject Ho and accept H, there is a strong negative correlation between age and ratio of leaf area to woody stem area, as there is less than 5% possibility the correlation is due to chance → significant result.

ResultsPlus
Examiner Comments

This answer gained all the marks. In Q08(b)(i), the table is completed correctly and in Q08(b)(ii) the value is calculated. The candidate goes on to interpret the test correctly by choosing the correct critical value, stating that the value is greater and going on to state that there is a negative correlation at a particular level of significance.

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A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

The student carried out a Spearman's rank correlation test using the data in the table.

Age of heather plant / years	Rank of age of heather plant	Ratio of leaf area : woody stem area	Rank of leaf area : woody stem area	d	d^2
16	4	0.7	4.5	–0.5	0.25
15	5	0.4	8	–3	9
12	6	0.6	6	0	0
4	9	2.0	1	8	64
7	8	1.1	2.5	5.5	30.25
22	1	0.2	10	–9	81
20	2	0.3	9	–7	49
3	10	1.1	2.5	7.5	56.25
17	3	0.5	7	–4	16
11	7	0.7	4.5	2.5	6.25

(i) Calculate the missing values to complete the table.
Write your answers in the table.

(2)

(ii) Calculate the Spearman's rank correlation coefficient for the data in the table.
Use the formula

$$r_s = 1 - \frac{6\sum d^2}{n\left(n^2 - 1\right)}$$

(3)

$\Sigma d^2 = 312 \times 6 = 1872$

$n = 10 \quad n^2 - 1 = 99 \quad 10 \times 99 = 990$

$1 - \frac{1872}{990} = 1 - 1.89 = -0.89$

Answer -0.89

(iii) The table gives some critical values for the Spearman's rank correlation coefficient.

n	Level of significance	
	$P = 0.05$	$P = 0.01$
5	1.000	–
6	0.886	1.000
7	0.786	0.929
8	0.738	0.881
9	0.700	0.833
10	0.648	0.794
11	0.618	0.755

Comment on the relationship between the age of the heather and the ratio of leaf area to woody stem area.

Use your calculated value of Spearman's rank correlation coefficient and the table.

(3)

$-0.89 < 0.648$ $\quad 1 - 0.891 = 0.89 > 0.648$

the modulus of the correlation coefficient is greater than the $p = 0.05$ level of significance therefore there is sufficient evidence to reject the null hypothesis and therefore there is a correlation between the age of heather and ratio of leaf area to woody stem area. The correlation is a negative correlation as it is $-0.89 < 0$.

ResultsPlus
Examiner Comments

This answer gained both marks for correctly completing the table in Q08(b)(i), three marks

for correctly calculating the coefficient in Q08(b)(ii) and three marks for identifying the correct critical value, stating that the value is greater than the critical value and stating that there is a negative significant correlation (the candidate refers to the significance level).

(b) As heather plants age, the ratio of leaf area to area of woody stem changes.

A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

The student carried out a Spearman's rank correlation test using the data in the table.

Age of heather plant / years	Rank of age of heather plant	Ratio of leaf area : woody stem area	Rank of leaf area : woody stem area	d	d^2
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20	2	0.3	9	–7	49
3	10	1.1	2.5	7.5	56.25
17	3	0.5	7	–4	16
11	7	0.7	4.5	2.5	6.25

(i) Calculate the missing values to complete the table.
Write your answers in the table.

(2)

(ii) Calculate the Spearman's rank correlation coefficient for the data in the table.
Use the formula

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

1872 / 990

$\Sigma d^2 = 312$
$\times 6$
$= 1872$

$10(10^2-1) = 990$

$= 1.890909$
$1 - \text{ans}$
$= -0.890909$

(3)

-0.89

Answer .....

(iii) The table gives some critical values for the Spearman's rank correlation coefficient.

n	Level of significance	
	$P = 0.05$	$P = 0.01$
5	1.000	–
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7	0.786	0.929
8	0.738	0.881
9	0.700	0.833
10	0.648	0.794
11	0.618	0.755

Comment on the relationship between the age of the heather and the ratio of leaf area to woody stem area.

Use your calculated value of Spearman's rank correlation coefficient and the table.

(3)

· critical value ~~at~~ is 0.648 at 0.05 significance.
This is smaller than ~~critical~~ calculated value of -0.891.
· reject null hypothesis, accept hypothesis that there is a significant relationship between the age of heather and the ratio of leaf area to woody stem area, there is a negative correlation because calculated value is negative, so as the age of heather increases, the ratio of leaf area to woody stem area decreases.

ResultsPlus
Examiner Comments

This answer also gained two marks for Q08(b)(i) and three marks for Q08(b)(ii) for correctly

completing the table and calculating the coefficient. Three marks were awarded for part Q08(b)(iii) as the candidate states that the value is greater than the correct critical value and explains that there is a significant negative correlation.

(b) As heather plants age, the ratio of leaf area to area of woody stem changes.

A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

The student carried out a Spearman's rank correlation test using the data in the table.

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3	10	1.1	2.5	7.5	56.25
17	3	0.5	7	–4	16
11	7	0.7	4.5	2.5	6.25

(i) Calculate the missing values to complete the table.
Write your answers in the table.

(2)

(ii) Calculate the Spearman's rank correlation coefficient for the data in the table.
Use the formula

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

$\Sigma d^2 = 312$

$6 \times 312 = 1872$

990

$= 1.89$

(3)

Answer 1.89

(iii) The table gives some critical values for the Spearman's rank correlation coefficient.

n	Level of significance	
	$P = 0.05$	$P = 0.01$
5	1.000	–
6	0.886	1.000
7	0.786	0.929
8	0.738	0.881
9	0.700	0.833
10	0.648	0.794
11	0.618	0.755

Comment on the relationship between the age of the heather and the ratio of leaf area to woody stem area.

Use your calculated value of Spearman's rank correlation coefficient and the table.

(3)

Using my calculated value we reject the null hypothesis and say that the age of the heather has an effect on the ratio of leaf area to woody stem area. The younger heathers have a greater ratio than the older heathers do. This is consistent as no heather older than 7 had a ratio of 1.1 or above

ResultsPlus
Examiner Comments

This answer gained two marks for Q08(b)(i) for correctly completing the table. Two marks were awarded for Q08(b)(ii) as 1.89 has been calculated but not subtracted from 1. The interpretation is vague and has no reference to significance or critical values and so gains no

marks.

(b) As heather plants age, the ratio of leaf area to area of woody stem changes.

A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

The student carried out a Spearman's rank correlation test using the data in the table.

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22	1	0.2	10	–9	81
20	2	0.3	9	–7	49
3	10	1.1	2.5 ~~3.5~~	~~7.5~~	56.25
17	3	0.5	7	–4	16
11	7	0.7	4.5	2.5	6.25

= 312

(i) Calculate the missing values to complete the table.
Write your answers in the table.

(2)

(ii) Calculate the Spearman's rank correlation coefficient for the data in the table.
Use the formula

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

$1 - \frac{6 \times 312}{10(10^2-1)} = \frac{1872}{10 \times 99} = \frac{1872}{990}$ **(3)**

$= 1.890909091$

$= 1.89$

Answer 1.89

(iii) The table gives some critical values for the Spearman's rank correlation coefficient.

n	Level of significance	
	$P = 0.05$	$P = 0.01$
5	1.000	–
6	0.886	1.000
7	0.786	0.929
8	0.738	0.881
9	0.700	0.833
10	0.648	0.794
11	0.618	0.755

Comment on the relationship between the age of the heather and the ratio of leaf area to woody stem area.

Use your calculated value of Spearman's rank correlation coefficient and the table.

(3)

The criticle value is 0.648. The calculated value is 1.89. This means the results are significant, because the calculated is higher then the critical value. This means there is a causal relationship between the age of the heather and ratio of leaf area : Woody stem ~~leaf~~ area. The results were not due to chance so the null hypothesis should be ~~neg~~ rejected.

ResultsPlus
Examiner Comments

This answer gained two marks for Q08(b)(i) as the table is correct. Two marks were awarded for Q08(b)(ii) as 1.89 has been calculated but not subtracted from 1. The value has then

been used correctly in Q08(b)(iii) – the candidate states that the value is greater than the correct critical value and so gains two marks.

(b) As heather plants age, the ratio of leaf area to area of woody stem changes.

A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

The student carried out a Spearman's rank correlation test using the data in the table.

Age of heather plant / years	Rank of age of heather plant	Ratio of leaf area : woody stem area	Rank of leaf area : woody stem area	d	d^2
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3	10	1.1	2.5	7.5	56.25
17	3	0.5	7	–4	16
11	7	0.7	4.5	2.5	6.25

(i) Calculate the missing values to complete the table.
Write your answers in the table.

(2)

(ii) Calculate the Spearman's rank correlation coefficient for the data in the table.
Use the formula

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

6×312

1872

$10(10^2 - 1)$

1.89

(3)

Answer 0.89

(iii) The table gives some critical values for the Spearman's rank correlation coefficient.

n	Level of significance	
	$P = 0.05$	$P = 0.01$
5	1.000	–
6	0.886	1.000
7	0.786	0.929
8	0.738	0.881
9	0.700	0.833
10	0.648	0.794
11	0.618	0.755

Comment on the relationship between the age of the heather and the ratio of leaf area to woody stem area.

Use your calculated value of Spearman's rank correlation coefficient and the table.

(3)

The calculated value (0.89) is higher than the critical value (0.7) showing that there is a strong correlation between the age of heather and water there's a different ratio between leaf and woody on the plant the ~~eyhl~~ So you reject the null

ResultsPlus
Examiner Comments

This answer gained two marks for Q08(b)(i) as the table is correct. Two marks are awarded for Q08(b)(ii) as 0.89 is the result of a correct calculation but the candidate has not stated

that it is negative (-0.89). One mark was awarded for Q08(b)(iii) as the candidate states that the value is greater than the critical value but has given the wrong critical value.

Question 8(c)

This question was the first of two six mark, level-based questions. The question required candidates to discuss the advantages and disadvantages of rewilding and burning of grouse moors after interpretating information about grouse moors and analysing the data showing how leaf surface area ratio changes with age thus affecting productivity. To gain level 3, candidates needed to consider the leaf area ratio (productivity), rewilding and burning. Many candidates scored at least two marks with a significant number going on to gain four marks. Fewer went on to gain level 3 (five or six marks) as many did not mention the data in the table about leaf area ratio and age of heather (the effect of age on productivity). Candidates who only considered one aspect in their answer tended to gain one mark but many considered rewilding and burning to gain three or four marks.

*(c) Farmers manage heather moors by burning the heather every 10 years. This removes older heather and allows younger plants to grow.

Managing heather moors by burning is controversial.

It has been suggested that instead of burning the heather, the moors should be left to return to nature as part of a rewilding strategy.

Rewilding strategies aim to return areas of farmland to the original ecosystems that existed before the heather moors.

Several factors have to be considered before a decision on rewilding is made.

- The heather moors are areas of peat containing dead organic waste that decomposes very slowly.
- Heather moors are an area of income for farmers.
- Over time, heather becomes very dominant and lies flat over the ground, blocking light.
- A variety of small species of plants live around areas of older heather.
- Heather seeds need to be heated to germinate efficiently.
- Some endangered species consume grouse.
- Grouse are raised by humans for profit.
- Heather moors have been managed for many years and many species that lived in the area are now extinct.

Analyse all the information in the question to discuss the effects of rewilding the moors compared with management by burning.

(6)

- Rewilding the moores will give rise to natural diversity within the area, which has positive ~~effe~~ affects on surrounding wildlife, with polinators such as bees being able to spread poller between rewilded and surrounding land. It would also provide more habitat for local wildlife reducing effects of distruption to certain areas of said habitat. However, if heather is left to grow naturally, it reduces the ability of any large plants growing successfully due to reduced light, which in turn reduces the effective habitat increase for surrounding species. Furthermore, it reduces possible income for farmers. Burning on the other hand incentivises farmers to take action towards ~~ra~~ protecting endangered ~~protected~~ species by raising ~~increas~~ grouse, however as these species are predators, they may try to cull them to protect the grouse, or prevent interaction. As the moors have slow decomposing peat, burning will return minerals such as nitrates to soil for plant life. However in doing so it releases large quantities of CO_2 which is a greenhouse gas, as well as killing any orgaisms in the field. Considering they have been managed for many years and species are still going extinct, it is likely this system has been shown to not be beneficial.

(Total for Question 8 = 15 marks)

ResultsPlus
Examiner Comments

This is a good answer that gained four marks (level 2). The candidate has considered many aspects of both rewilding and burning of the grouse moors but has not referred to the data in the table.

*(c) Farmers manage heather moors by burning the heather every 10 years. This removes older heather and allows younger plants to grow.

Managing heather moors by burning is controversial.

It has been suggested that instead of burning the heather, the moors should be left to return to nature as part of a rewilding strategy.

Rewilding strategies aim to return areas of farmland to the original ecosystems that existed before the heather moors.

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- The heather moors are areas of peat containing dead organic waste that decomposes very slowly.
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- Heather seeds need to be heated to germinate efficiently.
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- Grouse are raised by humans for profit.
- Heather moors have been managed for many years and many species that lived in the area are now extinct.

Analyse all the information in the question to discuss the effects of rewilding the moors compared with management by burning.

(6)

Heather moors = HM in question

HM contains a variety of animals & plant species which are part of the ecosystem

as the respire they release heat which is trapped in HM acts as protection from ~~bugs~~ predators

it will decrease the biodiversity and genetic variation

Burning could cause more damage like wild fires which are uncontrollable which will burn every thing on the land and may harm people or animals in the process

Some people think its wrong &/or unethical to burn the HM, due to some wanting them for aesthetic reasons

~~Burning~~ Managment by burning HM will contribute to global warming as it releases greenhouse gases that gets trapped by infrared radiation
es: water vapour & carbon dioxide

After the ~~burning~~ burning only occurs every 10 years

HM also supply locals & farmers with jobs and income So if they are gone they will be in financial distress However HM have made endangered species

~~For aesthetic reasons~~ go extinct as there limit of food source or grouse & due to high competition, & selective pressure increase

(Total for Question 8 = 15 marks)

ResultsPlus
Examiner Comments

This answer gained two marks. The candidate has commented on several benefits and

drawbacks of burning but has not mentioned anything from the table or about rewilding.



Always explore all aspects of data when answering 'discuss' questions.

*(c) Farmers manage heather moors by burning the heather every 10 years. This removes older heather and allows younger plants to grow.

Managing heather moors by burning is controversial.

It has been suggested that instead of burning the heather, the moors should be left to return to nature as part of a rewilding strategy.

Rewilding strategies aim to return areas of farmland to the original ecosystems that existed before the heather moors.

Several factors have to be considered before a decision on rewilding is made.

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- Heather moors are an area of income for farmers.
- Over time, heather becomes very dominant and lies flat over the ground, blocking light.
- A variety of small species of plants live around areas of older heather.
- Heather seeds need to be heated to germinate efficiently.
- Some endangered species consume grouse.
- Grouse are raised by humans for profit.
- Heather moors have been managed for many years and many species that lived in the area are now extinct.

Analyse all the information in the question to discuss the effects of rewilding the moors compared with management by burning.

(6)

Managing by burning can remove older less productive heather and allow younger heather with a higher NPP to grow. However, this is combustion which releases CO_2 into the atmosphere contributing to global warming through the enhanced greenhouse effect. Removing heather may reduce farmers' incomes and less areas for grouse and sheep which make money for people. It will likely also lead to a decline in some endangered species that consume grouse and will have less food which may cause them to become extinct. Some small plant species also rely on older ~~or~~ heather to live around as it occupies a niche of shelter so biodiversity may actually fall as a result of rewilding. However despite management many species have already gone extinct so returning to original ecosystems may help to combat the negative effects humans have likely had on the area, allowing a climax community to be reached. Heather seeds need to be heated to germinate though which relies on human intervention. Removing heather moors will mean there's less peat for the slow decomposition of organic waste which is necessary for nitrification of soils. Overall rewilding may allow a more biodiverse climax community and ecosystem to form as heather will no longer dominate and block light from other plants for photosynthesis. It will likely lead to more larger trees growing which also take in more carbon dioxide and less will be released through burning helping to slow down the release of greenhouse gases and global warming.

(Total for Question 8 = 15 marks)

ResultsPlus Examiner Comments

This is an excellent answer that gained all six marks. All three areas (productivity, rewilding and burning) are considered and there are many comments about them.

*(c) Farmers manage heather moors by burning the heather every 10 years. This removes older heather and allows younger plants to grow.

Managing heather moors by burning is controversial.

It has been suggested that instead of burning the heather, the moors should be left to return to nature as part of a rewilding strategy.

Rewilding strategies aim to return areas of farmland to the original ecosystems that existed before the heather moors.

Several factors have to be considered before a decision on rewilding is made.

1 • The heather moors are areas of peat containing dead organic waste that decomposes very slowly.

2 • Heather moors are an area of income for farmers.

3 • Over time, heather becomes very dominant and lies flat over the ground, blocking light.

4 • A variety of small species of plants live around areas of older heather.

5 • Heather seeds need to be heated to germinate efficiently.

6 • Some endangered species consume grouse.

7 • Grouse are raised by humans for profit.

8 • Heather moors have been managed for many years and many species that lived in the area are now extinct.

For burning
1, 2, 3, 5

against
4, 6, 7, 8

Analyse all the information in the question to discuss the effects of rewilding the moors compared with management by burning.

(6)

On the one hand, there is a variety of evidence that supports management by burning. Firstly, the heather moors are areas of peat containing dead organic matter that decomposes very slowly, hence, there would not be a significant supply of nutrients as plants if the area was kept to return to nature. The heather also allows for glucose light, thereby photosynthesis of smaller plants, hence why the value of long area: woody stem decorates are times as less sunlight is available. Many species * Although, despite the habitat The heather moors are also known, the heather moors are vital to local biodiversity, with many small species, as well as endangered species that confirm growth being reliant on the heather. Hence, allowing the heather to return to nature, will would help increase biodiversity. However, Furthermore, this will allow the farmers to raise more grouse, thereby reducing the economic impact of not burning the heather. Hence, overall rewilding should be considered as a more Furthermore, while burning temporarily removes older heather, it also promotes the seeds for heather to be germinated, creating a cycle. Thus, to the overall rewilding as a more viable strategy of management.

(Total for Question 8 = 15 marks)

* Thus, burning of heather may allow smaller plants to photosynthesise, encouraging growth.

ResultsPlus
Examiner Comments

This is another excellent answer that gained all six marks. The candidate has considered all three aspects and has many comments.

*(c) Farmers manage heather moors by burning the heather every 10 years. This removes older heather and allows younger plants to grow.

Managing heather moors by burning is controversial.

It has been suggested that instead of burning the heather, the moors should be left to return to nature as part of a rewilding strategy.

Rewilding strategies aim to return areas of farmland to the original ecosystems that existed before the heather moors.

Several factors have to be considered before a decision on rewilding is made.

- The heather moors are areas of peat containing dead organic waste that decomposes very slowly.
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- Grouse are raised by humans for profit.
- Heather moors have been managed for many years and many species that lived in the area are now extinct.

Analyse all the information in the question to discuss the effects of rewilding the moors compared with management by burning.

(6)

Burning the moors every 10 years allows for younger plants to grow. However, by burning the moors a large CO_2 amount will be released which contributes to the enhanced greenhouse effect. But by allowing young plants to grow this means that grouse have a better food source to survive on which maintains the biodiversity as endangered species consume grouse to survive so may go extinct without them. By rewilding original ecosystems would be reformed and this would allow plants beneath access to light and allow potentially more animals to enter the ecosystem to feed off these plants. As the moors after heather is dominant it will grow back even after burning. Secondary succession would occur and as the seeds require heat to germinate, the heather would begin to grow back quickly. The information suggests that the management of heather moors is not sustainable as many species have become extinct due to loss of habitat and selection pressures. Rewilding will cause increased biodiversity over time but will decrease profit of farmers so may not be possible.

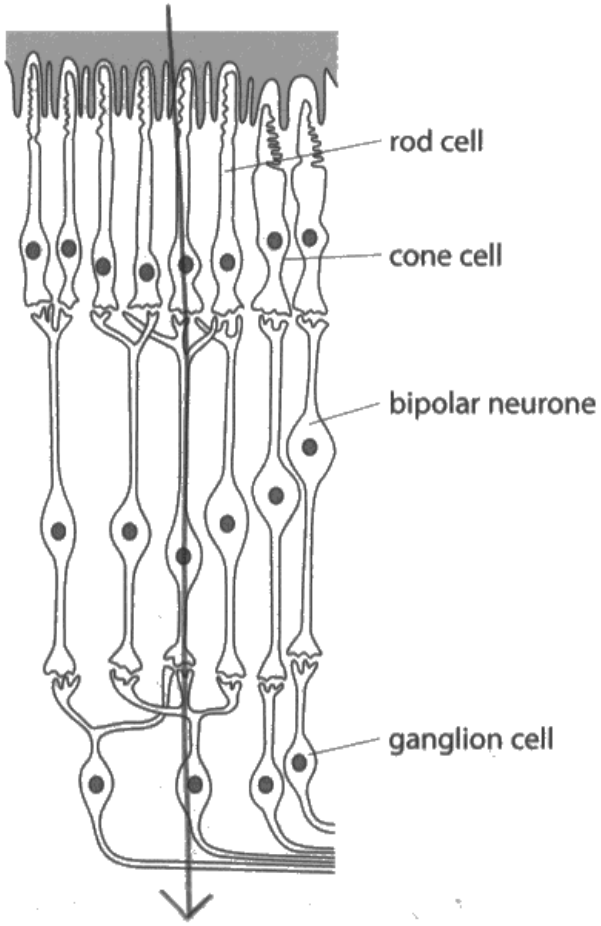
ResultsPlus
Examiner Comments

This is a good, strong answer with many points about burning and rewilding. There is no mention of the productivity / age of heather so the answer is level 2 and gained four marks.

Question 9(a)(i)

This question presented candidates with a diagram of a human retina. Candidates had to draw an arrow on the diagram to show the direction of light through the retina. Many correctly drew an arrow in the right direction (upwards) although a number drew the arrow incorrectly in the opposite direction.

9 The diagram shows a section through the central area of a human retina.



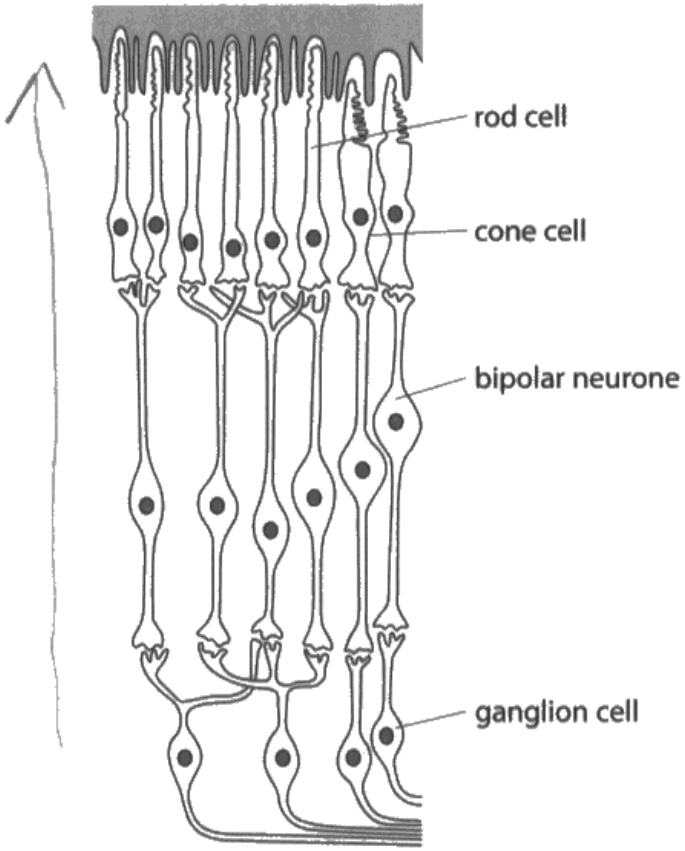
(a) (i) Draw an arrow on the left of the diagram to show the direction that light travels through the retina.

(1)

ResultsPlus
Examiner Comments

This answer did not gain the mark as the arrow points in the wrong direction.

9 The diagram shows a section through the central area of a human retina.



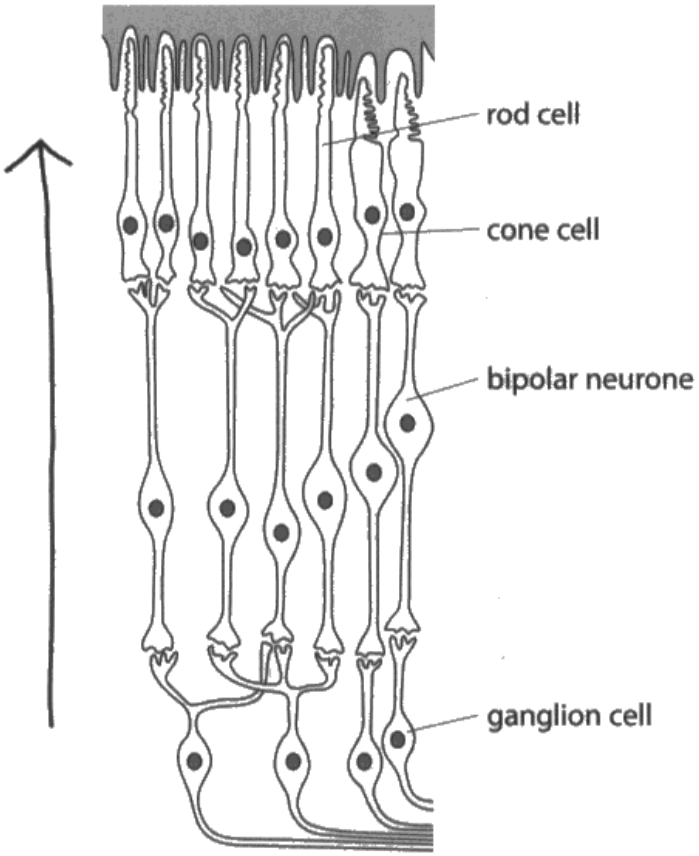
(a) (i) Draw an arrow on the left of the diagram to show the direction that light travels through the retina.

(1)

ResultsPlus
Examiner Comments

This arrow gained the mark as the arrow points in the correct direction.

9 The diagram shows a section through the central area of a human retina.



(a) (i) Draw an arrow on the left of the diagram to show the direction that light travels through the retina.

(1)

ResultsPlus
Examiner Comments

This answer also gained the mark as the arrow pointed in the correct direction.

Question 9(a)(ii)

This question was well answered by many candidates. The question asked candidates to describe how light absorbed by rhodopsin leads to a change in neurotransmitter from a rod cell. Many candidates correctly stated that rhodopsin breaks down into retinal and opsin, although a few candidates confused cis and trans retinal, incorrectly suggesting that light causes a change from trans-retinal into cis-retinal. Many went on to state that sodium channels are closed and that this causes a build up of sodium channels outside the rod cell membrane. Correct references to light stopping the 'dark current' were seen and many correctly stated that the membrane hyperpolarises. Many also went on to correctly state that neurotransmitter release stops. Some candidates incorrectly suggested that sodium channels open in the light and suggested that it would lead to an increase in neurotransmitter release.

(ii) Describe how light absorbed by rhodopsin in a rod cell leads to a change in release of neurotransmitter from the rod cell.

(3)

When rhodopsin absorbs light it is converted to retinal and opsin which is in control of the bleaching effect in rods.

ResultsPlus
Examiner Comments

This answer gained one mark. The candidate has correctly stated that rhodopsin breaks up into retinal and opsin but does not give any further detail.

(ii) Describe how light absorbed by rhodopsin in a rod cell leads to a change in release of neurotransmitter from the rod cell.

(3)

rhodopsin is a pigment. When light is absorbed by the rhodopsin it bleaches, changing colour. This chemical change stimulates an impulse to the brain releasing the neurotransmitter.

ResultsPlus
Examiner Comments

This is an example of an answer that gained no marks – the answer is very vague and gives no clear descriptions of the process.

(ii) **Describe how light absorbed by rhodopsin in a rod cell leads to a change in release of neurotransmitter from the rod cell.**

(3)

When light is absorbed by rhodopsin, it splits into opsin and retinal.

A photon of light hits the rhodopsin and the opsin binds to the membrane closing the Na^+ channels but not interfering with the movement of Na^+ ions in the membrane. The membrane becomes hyperpolarised ~~so inside of cell is~~ so it has a very negative charge. and makes an action potential

ResultsPlus
Examiner Comments

This answer gained three marks for correctly describing the breakdown of rhodopsin, the closure of Na^+ channels, and the hyperpolarisation of the membrane.

ResultsPlus
Examiner Tip

Make sure that you refer to 'sodium **ions**' or 'Na^+' rather than just 'sodium' or 'Na' when describing neuron activity.

(ii) Describe how light absorbed by rhodopsin in a rod cell leads to a change in release of neurotransmitter from the rod cell.

(3)

When light is absorbed by rhodopsin it is converted in opt retinal and cis retinal which enables the production of ions that facilitate in releasing neurotransmitters. to provide

ResultsPlus
Examiner Comments

This answer gained no marks. There are many key terms but the contexts are confused. The candidate has suggested that cis-retinal is produced.

(ii) Describe how light absorbed by rhodopsin in a rod cell leads to a change in release of neurotransmitter from the rod cell.

(3)

When light is absorbed by rhodopsin, it is bleached and turns into retinal and opsin. This now causes the sodium ion channel to close and reduces the release of neurotransmitters.

ResultsPlus
Examiner Comments

This answer gained three marks for the breakdown of rhodopsin, the closure of sodium channels and the prevention of neurotransmitter release.

Question 9(b)

This final, six mark, level-based question was well answered by many candidates. Candidates were given a diagram of a cat retina, data about the distribution of rods and cones in the cat retina, and data about the numbers of rods and cones in the retinas of nocturnal and diurnal animals. Many candidates gained at least three marks with many going on to gain five or six. Many candidates wrote excellent answers that used all three pieces of data and included their own knowledge about the summation of photoreceptors in retinas. To reach level 3, candidates needed to discuss the cat retina adaptations, other animals and include general information about the function of the retina. Where answers did not gain level 3, it was typically due to not including one or two pieces of information. The examiners were generally very impressed with the standard of answers. Many candidates understood the significance of nocturnal animals having more rod cells, recognised how the cat retina differed from the human retina and gave general information about how rod and cone cells function. Fewer identified more detailed features such as the different distribution of the saimiri monkey or the presence of cone cell summation in the retina of the cat.

rod cells - black and white Cone cells - Colour

Table 2

Species	When active	Total number of cells × 10^6	
		rod cells	cone cells
Rat	night	30	3
Night monkey	night	150	3
Marmoset monkey	day	6	11
Saimiri monkey	day	30	10

Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6)

• Cats hunt at night - when wavelengths are shorter due to darkness. therefore, more rods are needed than cones as rods are used to see black and white light - moving in the dark.

• Due to structure of retina, it can be seen that no spatial summation of rod cells occur, which means harder to achieve action potential / stimulate impulse. Therefore, more rods are needed to make up for lack of spatial summation.

• Humans do not hunt at night and have spatial summation, so have much fewer rod cells comparitively. ~~Human~~ Humans also have higher ~~rod~~ cone density as most active in day, absorb higher wavelengths, more colours of light.

• Similar pattern seen between rats and humans in terms of density of cones and rods around retina, majority of rods around ~~edge~~ edge of retina as concentration of cones is in fovea.
• Species active at night (rat / night monkey) show similar trend to cat, with high

(Total for Question 9 = 10 marks)

number of rod cells and lower number of cone cells, require rod cells to see low wavelengths of light in dark. Species active in the day (marmoset monkey and Saimiri monkey) have more cone cells - similar to humans, more active in the day, see more colours, need more cone cells to see longer wavelengths of light. Anomaly is ~~marmoset~~ Saimiri monkey, who is active during day but has more rod cells than cone cells. Could have similar anatomy to cat (ie takes spatial summation) therefore needs more rods to make up for it.

TOTAL FOR PAPER = 90 MARKS

ResultsPlus
Examiner Comments

This is an excellent answer that gained level 3. The cat retina is discussed alongside the other mammals. General points are made throughout about how the retina functions. There are many points so that the answer gained six marks.

Table 2

Species	When active	Total number of cells × 10^6	
		rod cells	cone cells
Rat	night	30	3
Night monkey	night	150	3
Marmoset monkey	day	6	11
Saimiri monkey	day	30	10

Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6)

Animals that are active at night have low light exposure. Rod cells are very sensitive to light and don't require much ~~for~~ light for an action potential to be released. This is due to ~~the~~ many rod cells ~~of~~ connections to one ~~rod~~ sensory neurone. Summation of potentials makes Rod cells more sensitive. ~~Cone cells~~ ~~However Rod~~ ~~cells~~ This allows night animals to see in the dark due to their higher number of rod cells. Daytime animals have lots of light exposure so they have less need for lots of rod cells. Instead

they have more Cone cells which can see colour. This is because the brain knows which cone cells are stimulated because one cone cell goes to one neuron. Cone cells less sensitive to light.

(Total for Question 9 = 10 marks)

ResultsPlus
Examiner Comments

This is a good answer that gained four marks (level 2). The candidate has considered the data about mammals and given general information but has not discussed the cat retina so the answer does not get level 3.

ResultsPlus
Examiner Tip

Make sure you use all the data when asked to 'discuss'.

Table 2

Species	When active	Total number of cells × 10^6	
		rod cells	cone cells
Rat	night	30	3
Night monkey	night	150	3
Marmoset monkey	day	6	11
Saimiri monkey	day	30	10

Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6)

Table 2:

• Rod cells are better adapted at absorbing low levels of light intensity

• Therefore, animals which are most active at night (rats and night monkeys) would have a higher total number of rod cells compared to cone cells

• Cone cells are better adapted at absorbing high levels of light intensity

• Therefore, the marmoset monkey would have higher number of cone cells for day activity

• The Saimiri monkey, whilst being active during the day has more rod cells than cone cells suggesting they operate in low light intensities

Table 1:

• Due to rats being night predators they have a much higher density of rod cells than cone cells as to

absorb more light during the nights low light intensity
• Humans opposite in both high and low light intensities
therefore having more similar amounts of rod and cone cells,
but higher cone as humans are more active during the day

ResultsPlus
Examiner Comments

This answer has information about the cats and data from the second table but no general points. Four key different points are made so the answer gained four marks.

Table 2

Species	When active	Total number of cells × 10^6	
		rod cells	cone cells
Rat	night	30	3
Night monkey	night	150	3
Marmoset monkey	day	6	11
Saimiri monkey	day	30	10

Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6)

The rat and night monkey, which are active at night have high numbers of rod cells and low numbers of cone cells. The low number of cone cells is due to the low light levels as cones require high light intensity and are unable to work in the dark. The cone cells are also used for colour vision which is not necessary in the dark. The animals active in the day have higher numbers of cone cells as they are able to absorb light in bright light allowing the animals to see in colour due to the pigments in cones which allow for the trichromatic theory of colour vision. The cat has the tapetum a reflective layer at the back of the retina as in the dark, it reflects the light to the rods and cones increasing the light absorbed, helping the cat to see better in lower light conditions. The cat has a much higher rod density as the rods work better in

dim although
~~bright~~ light and they have ~~a~~ lower visual acuity

Humans have higher cone density around the edge of retina than cats And cats have higher rod ~~cone~~

(Total for Question 9 = 10 marks)

TOTAL FOR PAPER = 90 MARKS

density around the edge of the retina than humans which allows them to have more rods to allow them to see better in lower light conditions as it increases the chance of a ~~nerve impulse occurring~~ of the rod cell being depolarized and a nerve impulse being sent to the brain allowing the cat to be able to see better in lower light the marmoset has few rod cells as they are active in the day when it is bright so they don't need the ability to see in dim light but they have the highest number of cone cells increasing the ability to see in bright light and have better colour vision. Active at night more rods less cones Active in the day less rods more cones

ResultsPlus
Examiner Comments

This is also an excellent answer that has more than six points from each of the three areas. The answer was classed as level 3 and gained six marks.

Table 2

Species	When active	Total number of cells × 10^6	
		rod cells	cone cells
Rat	night	30	3
Night monkey	night	150	3
Marmoset monkey	day	6	11
Saimiri monkey	day	30	10

Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6)

Night monkey: nocturnal so has large numbers of rod cells as ~~as~~ rod cells only work in areas with low light intensity. Spacial summation allows small light intensity to overcome threshold + trigger an action potential. Fewer cone cells as no need to see colour in darkness. Rely on 'black + white' eyesight to see in dark.

Rat: have more rod cells than cone for same reason as night monkey - need to see clearly in dark but only 30 rod cells ($\times 10^6$) as compared to 150 ($\times 10^6$) as have smaller retinas as smaller eyes, so less rod cells needed.

Marmoset and Saimiri monkey: both active in day so fewer rod cells needed + more ~~cone~~ cone cells present as ~~one~~ cone cells work in high light intensities as one cone cell to each bipolar neurone

no spacial summation. Meaning that the light provided by sun is enough to trigger action potential in one cone cell. Rhodopsin more sensitive than iodopsin and so rod cells more likely to overcome threshold of one bipolar cell, especially due to spacial summation. **(Total for Question 9 = 10 marks)**

TOTAL FOR PAPER = 90 MARKS

~~Human~~ Jaimin monkey has better eyesight than marmoset monkey.

Humans have higher cone density as compared to cats so utilise vision in day, whereas cats hunt at night so require more rod cells to see in a lower light intensity. Most rod cells located around edge of retina and not near the fovea so the cat can see more defined shapes in the dark as compared to humans.

Cats also have a reflective layer to reflect any light stimuli (even in low lighting) onto rod cells around edge of retina so so much stimuli is taken in as possible.

Cone cells mostly located at fovea.

Animals that hunt at night have more rod cells - see in low lighting. Spacial summation and overcomes threshold value ~~for~~ more easily so action potential stimulated in ~~bipo~~ bipolar neurone.

ResultsPlus
Examiner Comments

This answer was awarded six marks. There are general points, consideration of the cat retina, and discussion of other animals so it was classed as level 3.

Table 2

Species	When active	Total number of cells × 10^6	
		rod cells	cone cells
Rat	night	30	3
Night monkey	night	150	3
Marmoset monkey	day	6	11
Saimiri monkey	day	30	10

Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6)

The highest cone density of a human is 199000 cells with the highest rod density of 160000 cells compared to a cat with 270000 cone cells and 460000 rod cells. In humans the density of these cones are higher than those in cats whereas humans have a less dense rod cells around the edge of renna than cats. Rod cells are more active at night compared to at day.

ResultsPlus
Examiner Comments

This answer only considers the cat retina so it is classed as level 1. There are two or more points raised so the answer gains two marks.

Paper Summary

Based on their performance on this paper, candidates should:

- Ensure that they include detailed, accurate vocabulary for all questions.
- Check that their answers have detail that is commensurate with an A-Level standard.
- Be able to confidently interpret the results of statistical tests such as Spearman's rank, t-test, and chi-squared.
- Show all working when completing calculations.
- Use all data in a question when asked to discuss data.
- Describe patterns and then offer explanations when asked to 'comment on' data and / or explain data.

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