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June 2023

GCE Biology A 9BN0 03

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Introduction

The 9BN0_03 Biology paper focused on the general and practical application of the Pearson Edexcel GCE Biology Specification A. Aspects of all topic areas were considered and the paper included a series of question items linked to a pre-release scientific article. The paper included questions that targeted the conceptual and theoretical understanding of experimental methods, including mathematical analysis of experimental data.

The Summer 2023 paper offered a wide diversity of question styles that gave candidates many opportunities to display their knowledge and understanding of material from across the specification. It was pleasing to see candidates offering a range of encouraging responses that showed a good understanding of the material and much thanks should go to those who have taught them, as well as to the candidates themselves.

Successful candidates:

- demonstrated a familiarity with practical work and could devise investigations based on procedures they had carried out themselves.
- had studied the pre-released scientific article and read up on the aspects of biology within the article that they had encountered in their A-level Biology course.
- answered questions in the context set, showing that they had read the question.
- had learnt how to interpret the command words – such as 'determine', 'devise' and 'evaluate'.
- provided specific, relevant details to their answers.
- attempted every question.
- worked through calculations in a logical sequence, showing their working.
- demonstrated the ability to convert units and orders of magnitude.

Less successful candidates:

- re-wrote information from the question, using up time and space.
- did not answer questions in context, missing both the command word and the context.
- did not understand how to interpret the command words and therefore misinterpreted questions.
- left out vital details or wrote vague answers lacking relevant facts.
- did not attempt some questions – some answer spaces were left blank.
- made errors in calculations and did not provide clearly laid out workings.
- did not write clearly or legibly.
- wrote answers with poor grammatical construction that lost marks where the meaning was unclear.

Question 1 (a)

Candidates are asked to explain why many animals need a heart and circulation.

While many candidates gained both available marks others produced answers that lacked sufficient detail to gain credit. Mark Point 1 required the idea that the heart pumps blood around blood vessels. Many candidates simply stated, 'animals need a heart to pump blood'. Candidates could gain Mark Point 2 by referring to a requirement for bulk transport or an example of bulk transport. This mark was most frequently awarded for an example. Although lack of detail expected at A level meant the mark was often not awarded. For example, 'to pump oxygen around the body' was not sufficient. Answers needed to indicate where the oxygen was going eg 'to respiring cells' or 'to tissues' and not just to or around the body.

1 The heart pumps blood around the circulation system.

(a) Explain why many animals need a heart **and** circulation system.

(2)

. Animals need a hoart to pump hlood around tho circulatory system(mass flow system). Hoart pumps oxygenated and deoxygonatod blood.

.circulatory system required to overcomo limitations of simple diffusion small surface area to volume ratio. Have higher oxygen and metabolic demands. circulation system ensures this o provided quickly

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Examiner Comments

This response gained two marks. Mark Point 2 was awarded for 'mass flow system' which was allowed for mass transport (line 2). Mark Point 3 was awarded for the idea of needing to overcome the limitations of diffusion (line 4).

1 The heart pumps blood around the circulation system.

(a) Explain why many animals need a heart **and** circulation system.

(2)

animals surface area to volume ratio is too low for diffusion alone to provide cells with sufficient oxygen for aerobic respiration to produce ATP for energy. This means they need a mass transpat system with a heart to pump blood and circulatory stystem to transport blood around the body to provide cells with large enough supply of oxygen for aerobic respiration

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Examiner Comments

This response gained both available marks. Mark Point 3 first three lines, Mark Point 2 line 4 and again the last two lines. This response would not have been awarded Mark Point 1 as 'heart to pump blood around the body' was not sufficient. There needed to be a reference to blood vessels.

Question 1 (b)(i)

Most candidates gained the mark by correctly suggesting that cardiac muscle (we allowed the heart) is myogenic.

(b) If the heart of an animal is removed from its body, the heart will continue to beat for a period of time.

The left atrium stops contracting if it is separated from the rest of the heart.

However, the right atrium and the rest of the heart will continue to beat.

Eventually, the right atrium and the rest of the heart will also stop beating.

(i) Give a reason why the heart will continue to beat after being removed from the body.

(1)

heart muscle is myogenic

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Examiner Comments

A clear response that gained the mark.

Question 1 (b)(ii)

This question was answered well by many candidates. A number of candidates did not gain Mark Point 2 because they used the term signals rather than impulses. Signals is too vague and could mean something other than an electrical impulse.

(ii) Explain why the left atrium stops beating when it is separated from the right atrium.

(2)

The sinoatrial node that receives impulses that generate muscular contraction resides in the wall of the right atria. Therefore, separation will prevent impulses moving through the left atrium, and it will stop contracting

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Examiner Comments

A good response that gained Mark Point 1 in the first three lines and Mark Point 2 in the last two lines.

Question 1 (b)(iii)

A majority of candidates provided complete answers that gained both available marks, usually for Mark Point 1 and Mark Point 2. Some candidates described a lack of blood flow through the heart chambers which was not allowed for Mark Point 1. A number of candidates failed to finish the story with the idea of cells no longer being able to produce ATP, Mark Point 3.

(iii) Explain why the right atrium and the rest of the heart eventually stop beating.

(2)

The heart is no longer connected to blood vessels therefore they dont recieve oxygen & glucose from those blood vessels. After the heart runs out of oxygen it respires anaerobically & produces lactic acid. Heart runs out of glucose stores eventually & can no longer respire.

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Examiner Comments

This response gained both available marks. Mark Point 1 (line 2) and Mark Point 2 (line 4).

Question 2 (a)

For this question candidates were asked to calculate the volume of a neutrophil. They were provided with the diameter of a neutrophil and the formula for calculating the volume of a sphere. Most candidates completed the calculation correctly and gained both marks. Answers to one decimal place were accepted. If candidates did not provide a suitable final answer, then they could gain one mark if they demonstrated the use of 5^3 in their working.

There is an alternative way to complete the calculation of the volume of a neutrophil. Since the neutrophil diameter and therefor radius is half that of the monocyte the neutrophil volume will be $(^1/_2)^3$ or 1/8. Unfortunately, there is an error in the table provided to candidates. The volume quoted for the monocyte is incorrect. Candidates finding 1/8 the volume of the monocyte produced an answer of 39.3. This was accepted for both marks.

When asked to complete a table with a numerical value, candidates should consider the number of decimal places and significant figures used in other values in the table when writing their final answer.

2 White blood cells are involved in the non-specific and specific immune responses.

Neutrophils and monocytes are two types of white blood cell.

The table provides information about the neutrophils and monocytes of one individual.

(a) Complete the table to show the volume of each neutrophil.

Volume of a sphere $V = \frac{4}{3}\pi r^3$

(2)

Information	Neutrophil	Monocyte
Number of cells per mm^3 of blood	3000	400
Diameter of the cell / µm	10	20
Volume of each cell / μm^3	524	314

$\frac{4}{3} \times \pi \times 5^3 = 523.6$

$= 524$

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Examiner Comments

This response shows a correct calculation that gained both marks.

ResultsPlus
Examiner Tip

Although not instructed to the candidate has rounded to a whole number to match other values in the table. Answers to more than one decimal place did not gain both marks.

2 White blood cells are involved in the non-specific and specific immune responses.

Neutrophils and monocytes are two types of white blood cell.

The table provides information about the neutrophils and monocytes of one individual.

(a) Complete the table to show the volume of each neutrophil.

Volume of a sphere $V = \frac{4}{3}\pi r^3$

(2)

Information	Neutrophil	Monocyte
Number of cells per mm^3 of blood	3000	400
Diameter of the cell / μm	10	20
Volume of each cell / μm^3	105	314

$V = \frac{4}{3}\pi\left(\frac{10}{2}\right)^3$

$V = 104.7$

$V = 105\ \mu m^3$ (3sf)

ResultsPlus
Examiner Comments

In this response the candidate has made a mistake in the calculation. However, they have provided workings that clearly show they will find r^3, $(^{10}/_2)^3$. The first marking point can therefore be awarded.

Question 2 (b)(i)

To gain this mark a candidate response needed to describe the process with reference to an appropriate material eg pathogen, virus, microbe. Descriptions referring to 'engulfing material' or engulfing inappropriate material eg 'engulfing cells' did not gain the mark.

(b) The table shows some properties of neutrophils and monocytes.

Activated monocytes are called macrophages.

Property	Neutrophil	Monocyte
Material taken up by phagocytosis	Bacteria and fungi	Dead cell debris, bacteria and fungi
Antigen presentation	No	Yes
Production of cytokines	No	Yes

(i) State what is meant by the term phagocytosis.

(1)

the engulfing of a pathogen by a macrophage.
the pathogen is ingested and digested.

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Examiner Comments

A clear response that matches the mark scheme and gained the mark.

Question 2 (b)(ii)

Many good responses that gained all three available marks were seen. Unfortunately, candidates often failed to gain a marking point because of a lack of detail. In particular, to gain Mark Point 2 responses needed to make reference to antigen presentation to T cells. Many candidates simply referred to antigen presentation.

(ii) Explain why monocytes play a role in the antigen specific immune response to viruses but neutrophils do not.

(3)

monocytes can engulf the pathogen and then display the pathogens antigens in an MHC. This means that T-cells complementary to this antigen can bind to MHC – it can differentiate by cytokines released by monocyte. B specific B-cells can also differentiate forming antibodies specific to virus. However neutrophils do not become APC Antigen Presenting Cell or have cytokine so cannot influence the differentiation of specific T-cells and B-cells for virus.

(Total for Question 2 = 6 marks)

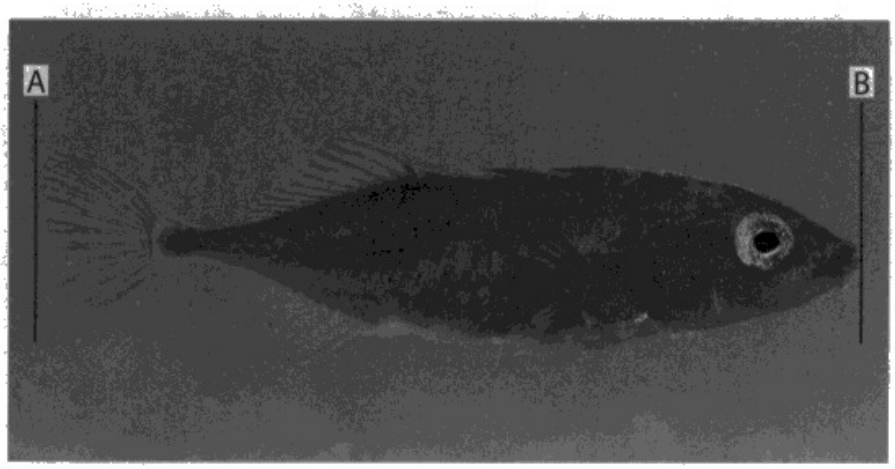
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Examiner Comments

In this response Mark Point 1 was awarded in the first line. Mark Point 2 was awarded for lines 2 to 4. Mark Point 3 was awarded for the idea that monocyte derived cytokines stimulate T cell differentiation, lines 3 to 5.

Question 3 (a)

This straightforward calculation was correctly completed by many candidates. A number failed to convert their answer into mm and gave 6 as their answer. Some candidates struggled to measure the length of the fish.

3 The photograph shows a three-spined stickleback (*Gasterosteus aculeatus*).



(Source: © ABS Natural History/Shutterstock)

Magnification × 1.8

This fish feeds on small invertebrates such as the brine shrimp (*Artemia salina*).

(a) Calculate the length of the stickleback between lines A and B.

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

(1)

108 mm = image

$\frac{\text{image}}{\text{actual}}$ = 1·8 actual = 108 ÷ 1·8 = 60

Answer 60 mm

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Examiner Comments

This correct calculation gained the mark.

Question 3 (b)(i)

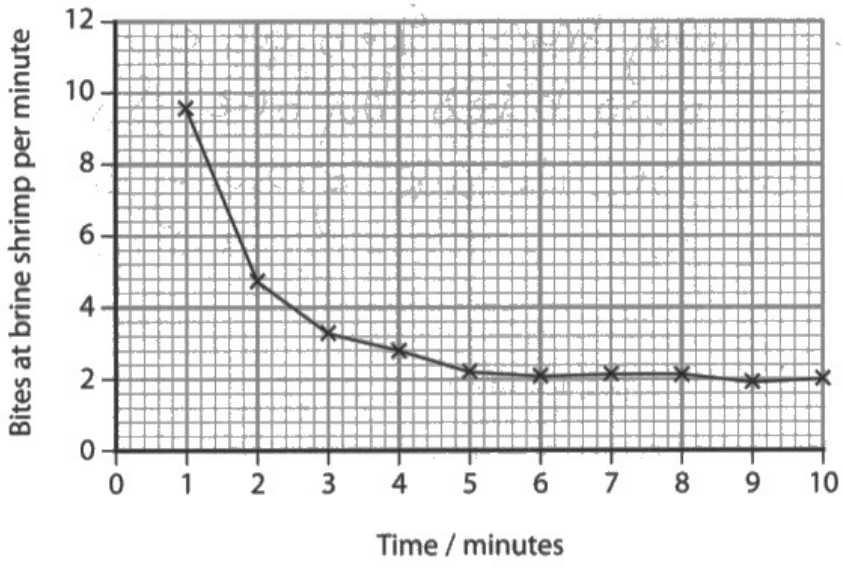
Many candidates correctly calculated an acceptable value for the percentage decrease.

Candidates who did not gain both marks were able to gain one mark for a correct calculation of the change (Mark Point 1). Unfortunately, a number of candidates do not show any working precluding the possibility of intermediate marks.

The stickleback tried to bite the brine shrimps in the tube.

The number of bites made by the stickleback was recorded each minute for 10 minutes.

The graph shows the results of this investigation.



(i) Calculate the percentage decrease in the number of bite responses from 1 to 6 minutes.

(2)

9.6 to 2

9.6-2

Answer $-\frac{4.75}{6}$

$\frac{2-9.6}{9.6} \times 100 = -79.16$

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Examiner Comments

This response gained one mark for a correct subtraction of values taken from the graph.

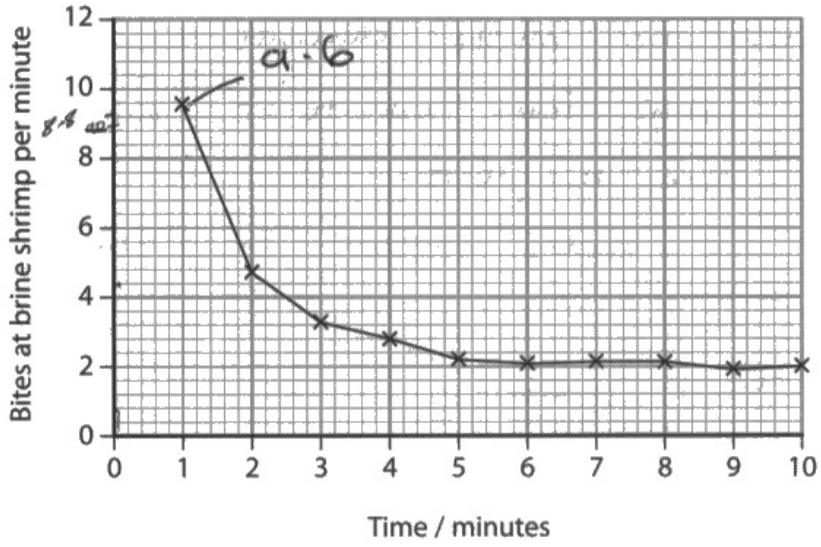
ResultsPlus
Examiner Tip

The answer on the answer line will be the answer that is marked. The answer on the answer line in this response was not accepted as the calculation has not been completed. The value – 79.16 recurring shown below the answer line would not have been accepted anyway. In general, answers should be rounded to an appropriate number of decimal places and not written as recurring values.

The stickleback tried to bite the brine shrimps in the tube.

The number of bites made by the stickleback was recorded each minute for 10 minutes.

The graph shows the results of this investigation.



(i) Calculate the percentage decrease in the number of bite responses from 1 to 6 minutes.

(2)

At 1 minute (old) = 9.6 bites.

At 6 minutes (new) = 2 bites.

$$\frac{\text{new} - \text{old}}{\text{old}} = \frac{2 - 9.6}{9.6} \times 100$$

79.2%

Answer [illegible]

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Examiner Comments

This response gained both marks for a correct answer. It is a rare, but useful, example of how candidates can lay out their workings.

ResultsPlus
Examiner Tip

Clearly laid out workings help examiners award intermediate marks if the final answer is incorrect.

Question 3 (b)(ii)

This question asked candidates to explain the results of an investigation. Many good responses were seen with candidates correctly describing the general trend shown by the graph (Mark Point 1). The majority of candidates recognised that the fish were becoming habituated (Mark Point 3). Marking points 2 and 4 were less frequently seen. Some candidates suggested that the fish eventually stopped seeing the brine shrimp as a threat. This was not allowed for Mark Point 4. A number of candidates gave elaborate detail of the mechanism by which a fish might become habituated which was not required.

(ii) Explain the results of this investigation.

(3)

As time increased, the number of bites at the ~~but~~ brine shrimp decreased. ~~The~~ After 6 minutes, the number of bites had decreased to 2 per minute and remained approximately the same as the stickleback had habituated. This is because fewer Ca^{2+} ions move into the pre-synaptic neurone ~~with~~ when an impulse arrives, therefore fewer vesicles containing neurotransmitter move towards and fuse with the presynaptic membrane therefore ~~fewer neu~~ less neurotransmitter is released into the synaptic cleft so less neurotransmitter binds to the receptors on the post-synaptic membrane so less Na^+ ions on the post-synaptic membrane open. Therefore, less Na^+ ions move across the post-synaptic membrane so the membrane is depolarised less and weaker action potentials are generated.

ResultsPlus
Examiner Comments

This response gained two marks. Mark Point 1 was awarded for the first two lines and Mark Point 3 for lines 5 and 6.

ResultsPlus
Examiner Tip

Read questions carefully. The question asks candidates to explain the results of an investigation. Two marks were gained in the first few lines. However, the response then developed into a detailed description of molecular events that might be taking place (lines 6 down). Unfortunately, this description does not explain the results and did not gain any credit.

(ii) Explain the results of this investigation.

(3)

Habituation has occured, each ~~time~~ as time went on the stickle back shewed less bites at the brine shrimp (after 6 minutes only two bites ~~at~~). This is because ~~the behaviour has~~ the ~~se~~ presynaptic neurone recieving an impulse as the fish sees the brine shrimp its receptors become less sensitive and responsive, ~~so a~~ and less ~~fe~~ Ca^{+} ions ~~dont~~ enter the ~~pre~~ neurone ~~so a neuro less~~ so less neurone is ~~+~~ neurotransmitter fuses with ~~the post~~ membrane to be released into the synaptic cleft to bind with complementary receptors on the post synaptic neurone, less depolarisation occurs therefore less action potential is generated. Therefore less responses are made, to conserve energy and not to waste it on ~~unecas~~ unecessary stimuli

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Examiner Comments

This response gained all three available marks. Mark Point 3 line 1, Mark Point 1 first two lines and Mark Point 4 last two lines. Lines 3 to 9 contain a lot of detail that is not required to answer this question.

Question 3 (c)

For this question candidates were given some additional information about breeding sticklebacks and then asked to devise an investigation. Many candidates produced good responses that scored well. Some candidates did not tell us they were using breeding males and did not gain Mark Point 1. Other candidates did not describe a method that would keep the males apart (Mark Point 4). Lack of detail often meant that Mark Point 5 could not be awarded. For example, descriptions of observing the attack response were not accepted for Mark Point 4.

(c) Adult male sticklebacks develop a red throat during the breeding season.

The male of a breeding pair of sticklebacks will attack a competing male in order to drive it away.

Devise an investigation to determine the effect of the presence of a competing male on the attack response of the male stickleback.

(4)

Take a male stickleback that is not in a breeding pair and has a red throat. Place this stickleback in a tank and allow it to acclimatise. Now seperate the tank using a dividing glass and on the otherside of the tank, place the male of a breeding pair. Now in every 1 min for 10 mins, record the number of times the male in a breeding pair tries to attack the other stickleback fish. Now repeat this data two more times or with different sticklebacks and calculate a mean. Make sure no control variable such as temperature, type species of stickleback, age of stickleback.

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Examiner Comments

This response gained four marks. Five marking points were seen. Mark Point 3 first two line, Mark Point 2 line 3, Mark Point 4 line 3 and 4, Mark Point 1 line 4 and 5 and Mark Point 5 lines 5, 6 and 7. The only marking point not addressed was a valid comparison between breeding and non-breeding challenger males, Mark Point 6.

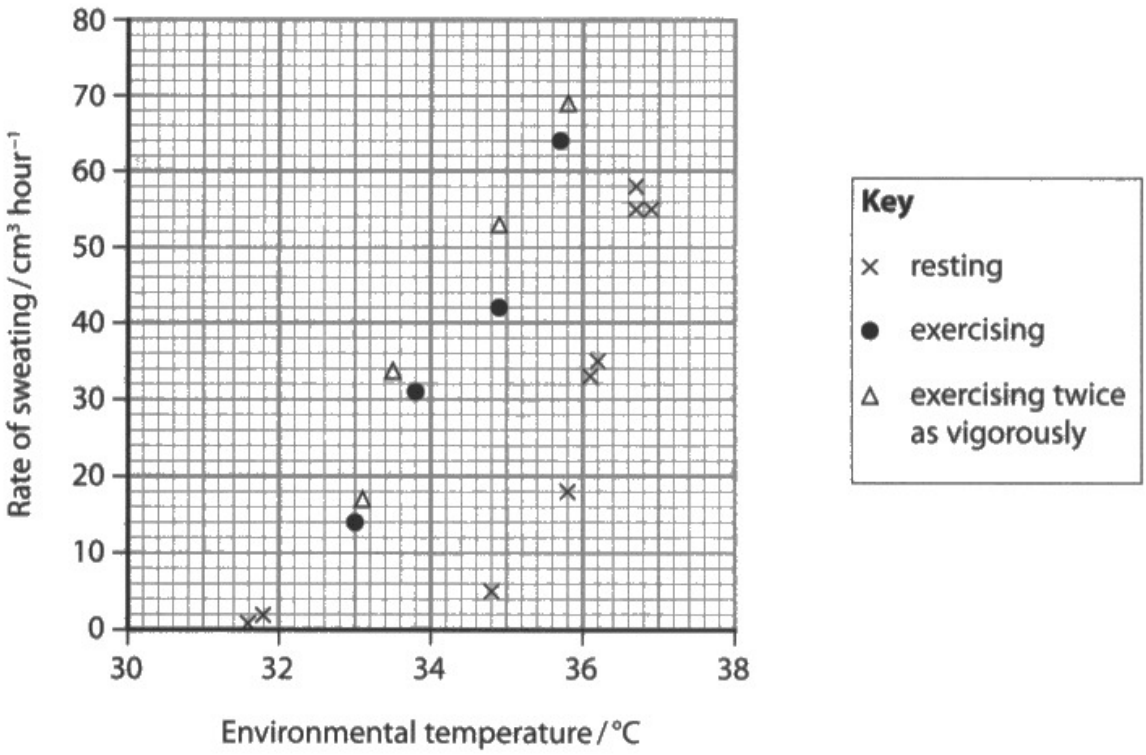
Question 4 (a)

A number of good responses were seen for this question. However, many candidates ignored the question and described the role of the dipole in dissolving or transporting polar substances.

Relatively few candidates described the use of heat or energy to break hydrogen bonds.

4 The effect of environmental temperature and exercise on the rate of sweating was studied.

The graph shows the results for one person.



(a) Explain the importance of the dipole nature of water in sweating.

(2)

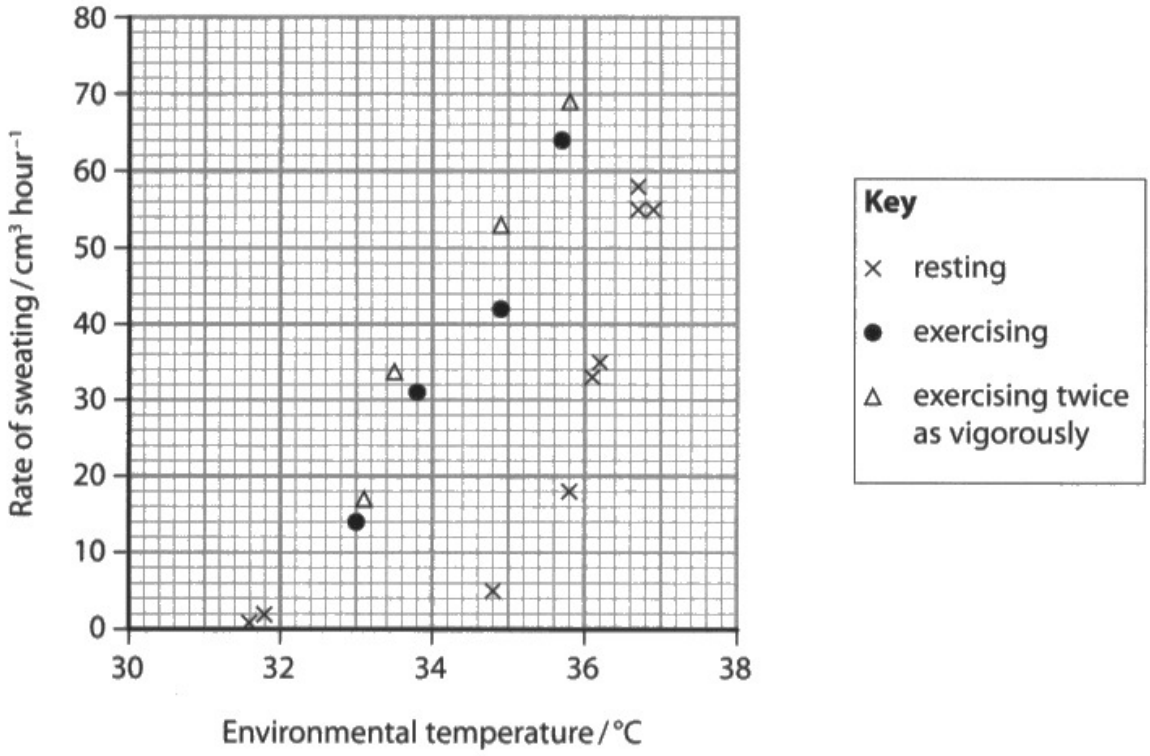
Due to its dipole nature, it has a slightly negative oxygen and 2 slightly positive hydrogen. therefore water molecules form hydrogen bonds between one another. These are very strong bonds, and so when sweat evaporates, heat energy from the body is used to break these bonds. This removes a large amount of heat from the body, so resulting in a decrease in body temperature.

ResultsPlus
Examiner Comments

This response gained both available marks. However, all three marking points are present, Mark Point 1 in line 2 and Mark Point 2 and 3 in line 4.

4 The effect of environmental temperature and exercise on the rate of sweating was studied.

The graph shows the results for one person.



(a) Explain the importance of the dipole nature of water in sweating.

(2)

- As temperature increases rate of sweating increases
- Hydrogen is polar
- Hydrogen is δ+ and oxygen is δ−
- can repel and attract water
- allowing water to cross through partially permeable membranes.

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Examiner Comments

This response did not gain any marks. The candidate appears to have ignored the question and started to describe the results in the graph above the question.

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Examiner Tip

Read questions carefully especially when a question comes below some data. The first question below a graph or table may not be asking you to describe the data.

Question 4 (b)

Many candidates misinterpreted this question. Candidates were asked to comment on the results of the experiment. They were not asked to comment on the design of the experiment or on the validity of the results. Candidates who understood the question often gained the first two or three marking points. Few candidates produced answers that gained all four available marks.

(b) Comment on the results of this study.

(4)

The results show that as environmental temperature increases, in all 3 conditions, the rate of sweating also increases. However in the resting condition a higher environmental temperature is needed for the rate of sweating to start increasing and then there is the lowest rate of sweat in this condition.

When exercising it needs a lot lower environmental temperature for rate of sweating to increase due to the core body temperature being increased.

When exercising twice as vigorously the temperature needed when rate of sweating is around the same as normal exercising but as rate of sweating is slightly higher at lower temperatures.

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Examiner Comments

This is an example of a good response. The candidate gained all four marking points. Mark Point 1 was awarded in the first two lines, Mark Point 4 was awarded in lines 3 and 4, Mark Point 2 in lines 5 and 6 and Mark Point 2 lines 11 to 12.

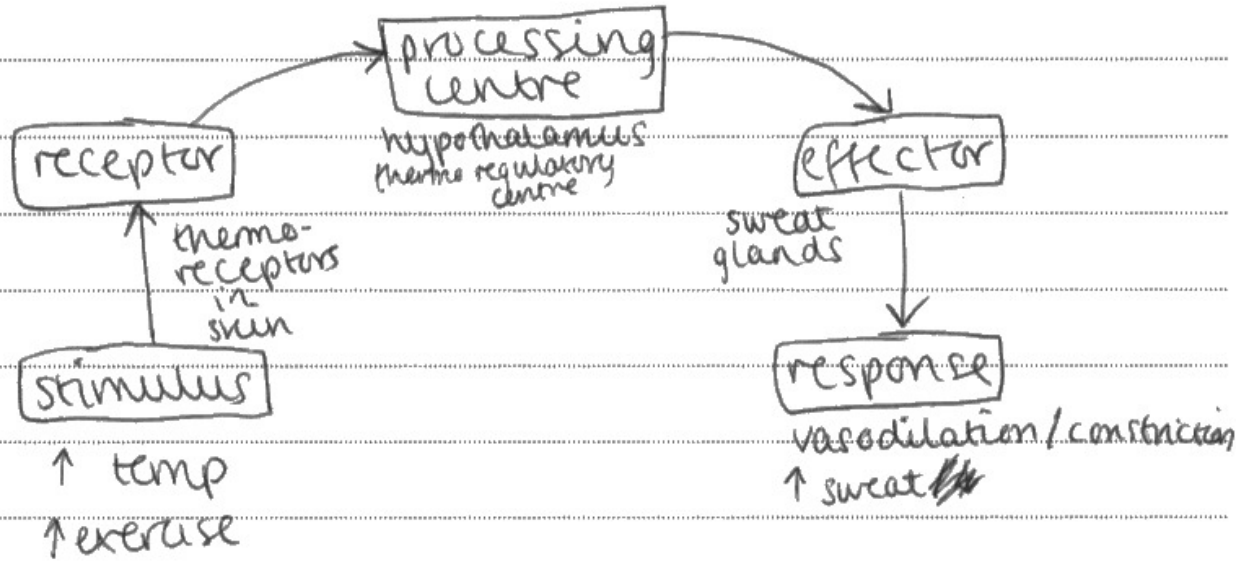
Question 4 (c)

Many candidates produced complete answers that gained all four available marks. Some candidates referred to thermoreceptors in the body and did not gain Mark Point 2. A number of candidates used terms such as 'stimulus' or 'signals' rather than 'impulses' and did not gain Mark Point 3 or 4.

(c) Describe how the production of sweat is controlled during exercise in humans.

(4)

Sweat glands



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Examiner Comments

This response gained 2 marks, Mark Point 2 left hand side of diagram and Mark Point 5 bottom right hand side of diagram. Mark Point 3 and 4 could not be awarded as there is no indication that the arrows in the middle of the diagram represent impulses.

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Examiner Tip

If you use a diagram to answer a question, make sure it is fully annotated with all relevant information.

(c) Describe how the production of sweat is controlled during exercise in humans.

(4)

• Thermoreceptors detect increase in temperature of body.
• Thermoreceptors send impulse to the hypothalamus' thermoregulation centre which processes the information and sends impulses to the effectors.
• Effectors in this case are the sweat glands which aim to restore regular/core body temperature by producing more sweat.
• As water in sweat evaporates from the surface of the skin, energy in the form of heat is also taken.

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Examiner Comments

Three marks were awarded for this response. Mark Point 3 for lines 3 and 4, Mark Point 4 lines 5 to 7 and Mark Point 5 line 9.

Mark Point 2 was not awarded for the first two lines as a relevant location for the thermoreceptors was not provided.

Mark Point 1 was not awarded for line 8 as it is not sufficiently clear that the candidate is referring to homeostasis or a negative feedback response.

Question 5 (a)(i)

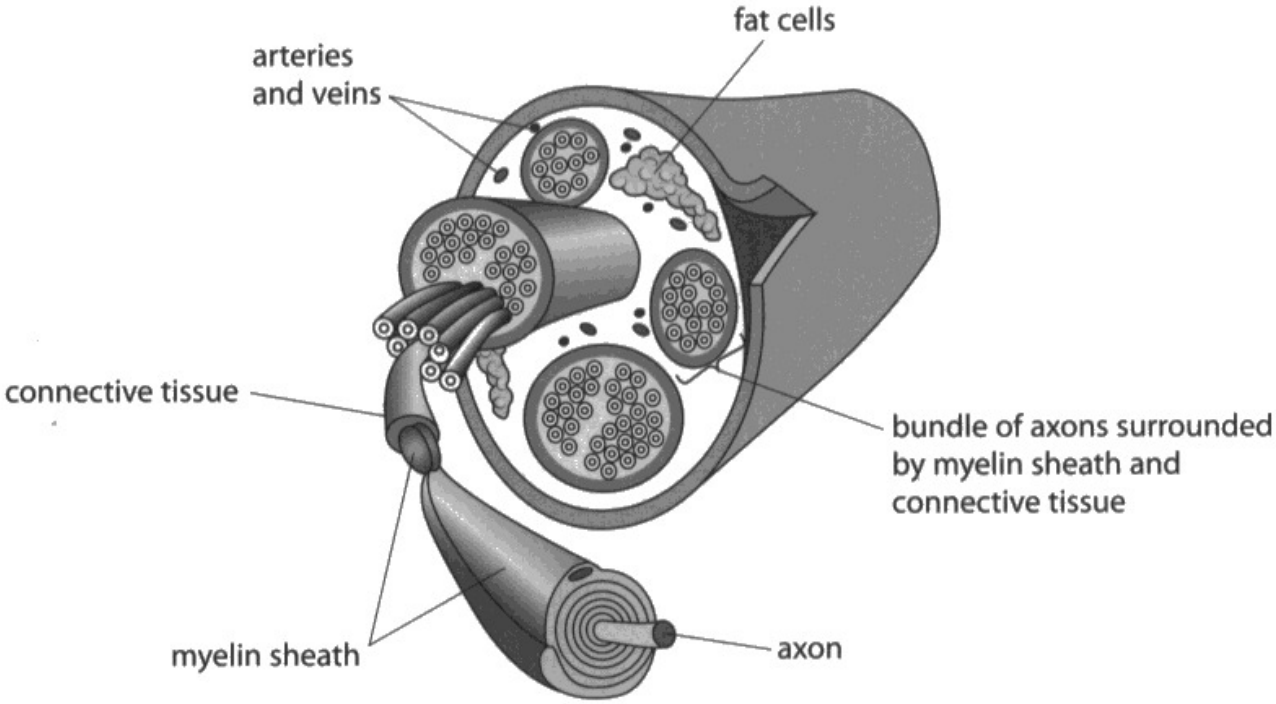
Candidates found this question very straightforward with very few not gaining the mark.

5 People with diabetes can suffer from a condition called diabetic peripheral neuropathy (DPN).

In DPN, peripheral nerves become damaged, affecting the transmission of nerve impulses.

Peripheral nerves are nerves that connect the central nervous system to all parts of the body. These nerves are formed from bundles of axons.

The diagram shows the structure of a peripheral nerve.



(a) Each axon is surrounded by a myelin sheath.

(i) Name the type of cell that forms the myelin sheath.

(1)

Schwann cells.

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Most candidates correctly named the Schwann cell.

Question 5 (a)(ii)

Many good responses were seen to this question with many candidates gaining both marks.

(ii) Describe the role of myelination in the conduction of a nerve impulse.

(2)

Myelination insulates the axon so ~~energy~~ action potential doesn't move down the whole axon but instead jumps from node of ranvier to node of ranvier by saltatory conduction which is faster.

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Examiner Comments

In this response Mark Point 1 was gained in the first line and Mark Point 2 in line three.

(ii) Describe the role of myelination in the conduction of a nerve impulse.

(2)

Myelenated Sheath speeds up conduction by saltatory conduction. (in myelin Sheath) Gaps, called Nodes of Ranvier ~~are~~ are used by impulses to jump between which means instead of travelling the whole distance of neuron/axon, they can jump between gaps, speeding up conductance

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Examiner Comments

This response only gained one mark, Mark Point 2.

Question 5 (a)(iii)

A number of candidates provided complete answers that gained all five available marks.

Some candidates included a lot of detail that was not required. For example, candidates sometime provided detail of events at the synapses and the role of the sodium-potassium ion pump in establishing a resting potential.

Marks were frequently lost for descriptions of sodium or potassium rather than their ions and for descriptions of ions diffusing into or out of membranes (Mark Point 2 and 5). To gain Mark Point 3 and 6 candidates needed to attribute depolarisation and repolarisation to the membrane and not simply say depolarisation or repolarisation occurs.

(iii) Describe the role of ion channels in the conduction of a nerve impulse.

(5)

When an impulse is conducted polarisation occurs.
The voltage gated ion channels open causing an
action potential. This increases voltage from -70mV
to 40mV. The ion channels then close and ~~stop~~
depolarisation occurs. Voltage decreases from 40mV
to -30mV. Repolarisation occurs and the ion channels
open increasing the voltage to 0mV at rest.

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Examiner Comments

Important details are missing throughout this response and it gained no marks.

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Examiner Tip

Make sure you include important details in your answers. For example, in this response which ion channels are opening (line 2) and closing (line 4) and what is being depolarised (line 5) and repolarised (line 6).

(iii) Describe the role of ion channels in the conduction of a nerve impulse.

(5)

*A stimulus causes voltage-dependent sodium ion channels to open, and Na^+ ions diffuse into the axon, causing depolarisation of the axon's membrane. After a certain point, voltage-dependent sodium ion channels close and voltage-dependent potassium ion channels open, causing K^+ ions to diffuse out of the axon, causing repolarisation of the axons membrane. Hyperpolarisation occurs and voltage-dependent K^+ ion channels close, which ensures that nerve impulse travels in one direction only.

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Examiner Comments

This is an example of a good response that gained all five available marks. All six marking points are seen in the response. Mark Point 1 line 1, Mark Point 2 line 2, Mark Point 3 line 3. Mark Point 4 lines 4 to 6, Mark Point 5 line 6 and Mark Point 6 lines 7 and 8.

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Examiner Tip

Compare this example with the previous example, can you see why this one gains marks and the previous response did not?

Question 5 (b)(i)

Most candidates correctly calculated a ratio as requested. If candidates did not state the order of A and B, it was assumed they were giving the ratio for A to B and not B to A.

Question 5 (b)(ii)

This question was answered well by many candidates. For Mark Point 1 candidates needed to describe damage to the cardiovascular system that would directly result in a reduction in blood flow.

(ii) Explain why these risk factors can cause peripheral nerve cells to die.

(3)

surrounding the bundles of of axons that make up the peripheral nerves, there are fat cells and there are arteries and veins. Smoking increases the risk of atherosclerosis, and so does High LDL : HDL ratio and high triglyceride levels. Atherosclerosis may reduce blood flow to peripheral nerve cells, causing them to die due to lack of oxygen and lack of aerobic respiration.

ResultsPlus
Examiner Comments

This response gained all three marks. Mark Point 1 lines 4 to 6, Mark Point 2 lines 6 and 7 and Mark Point 3 last 2 lines.

Question 6 (a)

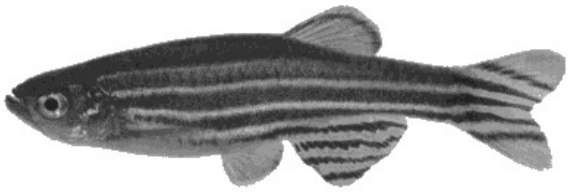
Many candidates provided good responses to this question. Candidates often gained all three available marks. Generally, candidates gained marks from the first three Mark Points. Relatively few candidates addressed Mark Point 4.

6 The zebrafish (*Danio rerio*) has been studied as a model for vertebrate development.

Zebrafish have a variety of types of stripes and fin shape phenotypes.

Wild type zebrafish are homozygous for the black stripe and short fin phenotypes.

The photograph shows a wild type zebrafish.



(Source: © Mirko_Rosenau/Shutterstock)

(a) The black stripes of zebrafish are produced by cells called melanophores.

Melanophores produce a black pigment called melanin.

Explain how a specialised cell such as a melanophore is produced from a stem cell.

(3)

1 The stem cell receives a chemical stimulus. Depending
2 on the chemical stimulus, certain genes are activated and
3 deactivated. Activated genes are transcribed into mRNA and
4 translated into proteins. Proteins then modify the cell, causing
it to differentiate and become a specialised cell such as
melanophore.

ResultsPlus
Examiner Comments

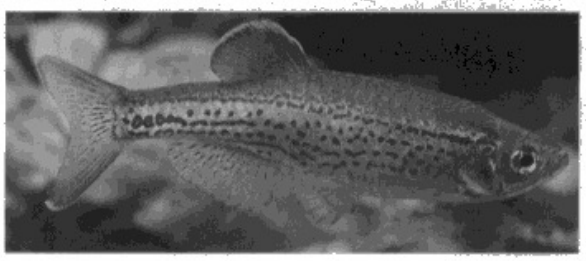
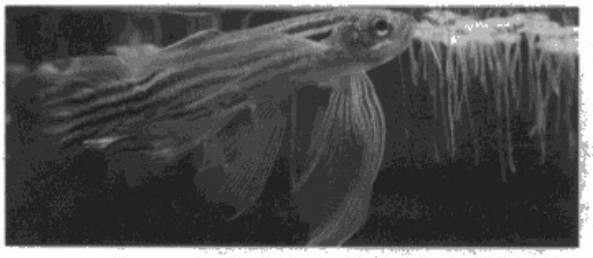
This response gained all three available marks. Mark Point 1 was awarded in line 1, Mark Point 2 in lines 2 and 3 and Mark Point 3 in lines 3 and 4. Mark Point 4 would not have been awarded for differentiation into a melanophore (last 2 lines). It needed candidates to make reference to the production of melanin.

Question 6 (b)(i)

To answer this question candidates needed to describe a change in the base sequence in DNA (or in a gene). Many candidates provided incomplete answers. Frequently, candidates forgot to tell us that the change involved DNA or a gene.

(b) Zebrafish with different phenotypes have been produced by introducing gene mutations into the zebrafish genome.

Two of these phenotypes, spots and long fin, are described in the table.

Phenotype name	Photograph	Description
spots	 (Source: © Grigorev Mikhail/Shutterstock)	melanin produced in spots instead of stripes
long fin	 (Source: © Grigorev Mikhail/Shutterstock)	long fins instead of short fins

In an investigation, the inheritance of these two phenotypes was studied.

In cross 1, one parent was homozygous for stripes and the other parent was homozygous for spots.

In cross 2, one parent was homozygous for short fins and the other parent was homozygous for long fins.

The table shows the results of this investigation.

Cross	Genotype of parent 1	Genotype of parent 2	Phenotype of the offspring
1	homozygous for stripes and short fins	homozygous for spots and short fins	all had stripes and short fins
2	homozygous for stripes and short fins	homozygous for stripes and long fins	all had stripes and long fins

(i) State what is meant by the term gene mutation.

(1)

New Gene develops a different base sequence from a ~~dd~~ original gene.

ResultsPlus
Examiner Comments

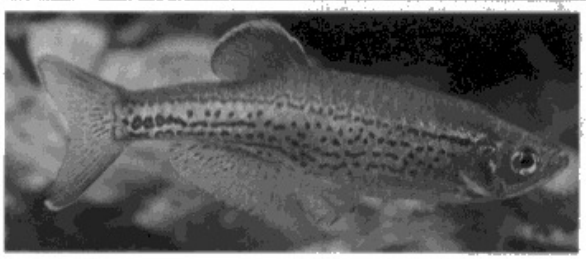
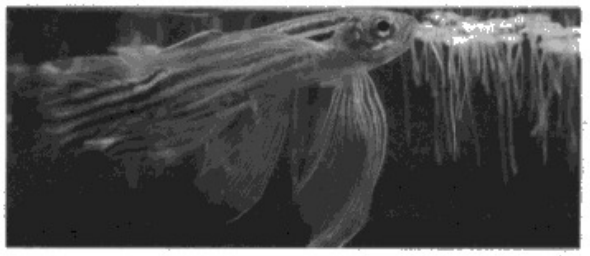
This response did not gain the mark.

ResultsPlus
Examiner Tip

Take care with biological terms such as gene. The terms we use have a specific meaning and must be used correctly. In this response the candidate is using the term gene incorrectly. Unfortunately, this has lost the candidate a mark. Gene mutation does not mean a new gene is produced, as suggested in this response.

(b) Zebrafish with different phenotypes have been produced by introducing gene mutations into the zebrafish genome.

Two of these phenotypes, spots and long fin, are described in the table.

Phenotype name	Photograph	Description
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Cross	Genotype of parent 1	Genotype of parent 2	Phenotype of the offspring
1	homozygous for stripes and short fins	homozygous for spots and short fins	all had stripes and short fins
2	homozygous for stripes and short fins	homozygous for stripes and long fins	all had stripes and long fins

(i) State what is meant by the term gene mutation.

(1)

A change in the sequence of bases in a DNA molecule

ResultsPlus
Examiner Comments

This is a clear description of the term gene mutation that gained the mark.

Question 6 (b)(ii)

Many candidates found this question straightforward and gained both marks. A number of candidates produced responses giving the pattern of inheritance for stripes and short fin phenotypes, which was not asked for in the question.

(ii) Deduce the pattern of inheritance of the spots and long fin phenotypes.

(2)

The table shows that the ~~the~~ spots is caused by a recessive gene as the phenotype of the offspring in cross 1 was striped. The table shows that long fins are caused by a dominant gene as shown by Cross 2 resulting in a phenotype of long fins. To have a spotty

ResultsPlus
Examiner Comments

In this response the candidate has used the term gene incorrectly and did not gain any credit.

ResultsPlus
Examiner Tip

Look at the examples in Q06(b)(i). Can you explain what the candidate has got wrong in this example?

(ii) Deduce the pattern of inheritance of the spots and long fin phenotypes.

(2)

stripe ~~acting~~ acting as dominant allele and long fin acting as dominant allele.

ResultsPlus
Examiner Comments

This example gained one mark, Mark Point 1 for long fin (phenotype) being the result of a dominant allele. Mark Point 2 requires a statement about the spot's phenotype not the stripes phenotype.

Question 6 (c)(i)

This question was well answered by the majority of candidates.

(c) Melanin pattern (stripes or spots) and fin length (long or short) are controlled by different genes.

Parents heterozygous for both these genes (DdNn) were crossed.

The table shows the expected genotypes of the parental gametes and the genotypes and phenotypes of the offspring.

The expected genotypes and phenotypes assume that genes for spots and long fins are inherited independently of each other.

(i) Complete the table by filling in the missing genotypes and phenotypes.

(2)

		Parent 1 gametes			
		DN	Dn	dN	dn
		Genotypes and phenotypes of offspring			
Parent 2 gametes	DN	DDNN stripes and long fins	DDNn stripes and long fins	DdNN stripes and long fins	DdNn stripes and long fins
	Dn	DDNn stripes and long fins	DDnn stripes and short fins	DdNn stripes and long fins	Ddnn stripes and short fins
	dN	DdNN stripes and long fins	DdNn stripes and long fins	ddNN spots and long fins	ddNn spots and long fins
	dn	Dd Nn stripes long fins	Dd nn stripes short fins	dd Nn spots long fins	dd nn spots short fins

ResultsPlus
Examiner Comments

This is a clear example of a correctly completed table that gained both marks.

Question 6 (c)(ii)

Many candidates were able to calculate a value for chi squared. A frequently seen error was to divide the $(O\text{-}E)^2$ value by the total (512).

(ii) The table contains the observed and expected results of this cross.

Phenotype	Observed number	Expected number
stripes and long fins	270	288
stripes and short fins	87	96
spots and long fins	115	96
spots and short fins	40	32
Total	512	512

Calculate a value for chi squared (χ^2).

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

(3)

$$\sum \frac{(270-288)^2 + (87-96)^2 + (115-96)^2 + (40-32)^2}{512}$$

$$\chi^2 = 1.621$$

(3 dp)

Answer 1.621

ResultsPlus
Examiner Comments

This example illustrates a fairly common mistake seen in candidate responses. Rather than dividing each $(O\text{-}E)^2$ by E the candidate has summed the $(O\text{-}E)^2$ values and divided by the total number of individuals observed.

(ii) The table contains the observed and expected results of this cross.

Phenotype	Observed number	Expected number
stripes and long fins	270	288
stripes and short fins	87	96
spots and long fins	115	96
spots and short fins	40	32
Total	512	512

Calculate a value for chi squared (χ^2).

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

(3)

$\frac{(270-288)^2}{288} + \frac{(87-96)^2}{96} + \frac{(115-96)^2}{96} + \frac{(40-32)^2}{32} = 7.73$

ResultsPlus
Examiner Comments

This response gained all three available marks for a correct answer. The workings are also clearly laid out so intermediate marks could have been awarded if the final answer had been incorrect.

ResultsPlus
Examiner Tip

It is a good idea to put your final answer on the answer line. Examiners will look elsewhere for the answer. However, if the workings are not clear or two different answers are seen they cannot pick and choose which workings or answer to mark. The risk then is that you do not gain the marks.

Question 6 (c)(iii)

Candidates often correctly stated that their calculated value was less than the critical value of 7.82 and gained Mark Point 1. Many of these candidates then went on to provide a generic answer, suggesting the null hypothesis could be accepted or rejected. However, in this case a null hypothesis had not been provided. To gain a second mark candidates needed to say something about the results. They could suggest that the observed results are not different to the expected results (Mark Point 2) or they could suggest that the traits are inherited independently of each other (Mark Point 3). A number of candidates made comments such as 'therefore there is no difference between the phenotypes' or 'therefore the genes are independently inherited'. Neither statement is correct and did not gain Mark Point 2 or 3.

(iii) Some critical values for the chi squared test (χ^2) are given in the table.

degrees of freedom	Critical value	
	p = 0.05	p = 0.01
1	3.84	6.64
2	5.99	9.21
3	7.82	11.35
4	9.49	13.28
5	11.07	15.09

State a conclusion that can be drawn from the results of this cross.

(2)

9.49 > 7.73

Therefore there is not a significant difference between the observed and expected results.

ResultsPlus
Examiner Comments

In this response the wrong critical value has been selected. The degrees of freedom for the data provided is 4 – 1 = 3. At p=0.05 this means the critical value is 7.82. The candidate has however, gone on and made a correct statement about the results and gains Mark Point 2.

(iii) Some critical values for the chi squared test (χ^2) are given in the table.

degrees of freedom	Critical value	
	p = 0.05	p = 0.01
1	3.84	6.64
2	5.99	9.21
3	7.82	11.35
4	9.49	13.28
5	11.07	15.09

State a conclusion that can be drawn from the results of this cross.

(2)

- The chi-squared value is lower than the critical period so results are not significant.
- reject alternative hypothesis and accept null hypothesis.

ResultsPlus
Examiner Comments

This response gained no marks. Even allowing for poor language it is not possible to award Mark Point 1 as there is no reference to 7.82 or 3 degrees of freedom. The statement about alternative and null hypothesis was ignored. Candidates were not given a null hypothesis (or a hypothesis) so cannot make a statement about whether or not to accept or reject it.

Question 7 (a)

Many good responses to this question were seen. Candidates frequently described M tuberculosis surviving inside macrophages (Mark Point 1) and surviving or remaining dormant in tubercules (Mark Point 2). Numerous candidates made reference to M tuberculosis avoiding the immune response but did not provide sufficient detail to gain Mark Point 3. A number of candidates ignored the question and described methods of transmission of TB.

7 Tuberculosis is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*.

(a) Describe how *M. tuberculosis* bacteria evade the immune system. (2)

M. Tuberculosis have a thick waxy capsid and cell wall so when macrophages engulf the bacteria, the bacteria cannot be digested so they are not destroyed. They lie dormant in the macrophages forming a tubercule. These tubercules cannot be broken down as the bacteria is hidden inside the macrophage and the immune system cannot detect the bacteria inside the

ResultsPlus
Examiner Comments

This response gained two marks. Mark Point 1 for the first three lines and Mark Point 2 for lines 3 and 4. Mark Point 3 would not have been awarded for the last two lines as insufficient detail is provided.

ResultsPlus
Examiner Tip

Notice this candidate response goes outside the answer space. In this case it does not matter as the candidate has already gained both marks. However, on other occasions if the marker does not realise your response goes outside the answer space the missing part of your answer may not be marked. Always indicate clearly if you have written outside the answer space.

Question 7 (b)(i)

To answer this question candidates needed to tell us that transcription factors are proteins that control genes transcription. Many candidates simply used the term 'factor' and did not gain this mark.

(b) The transcription factor STAT3 is involved in regulating the activity of macrophages and T cells.

(i) State what is meant by the term transcription factor.

(1)

a transcription factor is a protein that binds to a promoter region of a gene that aids the attachment of RNA polymerase so the gene can be ~~transcribed~~ translated into mRNA which then makes the protein.

ResultsPlus
Examiner Comments

Unfortunately, this candidate crossed out 'transcribed' and replaced it with 'translated' and did not gain the mark.

ResultsPlus
Examiner Tip

Make sure you know and can use correct biological terms found in the specification.

(b) The transcription factor STAT3 is involved in regulating the activity of macrophages and T cells.

(i) State what is meant by the term transcription factor.

(1)

a protein that activises or deactivises a gene to increase or decrase rate of transcription

ResultsPlus
Examiner Comments

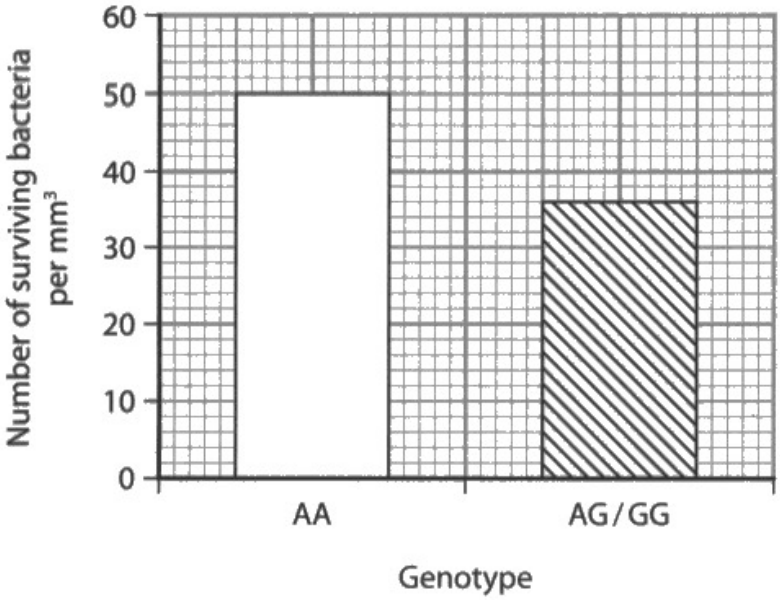
This is a clear and complete response that gained the mark.

Question 7 (b)(ii)

Q07(b)(ii) is a level-based question. Candidate responses were judged against generic criteria to determine the level of response. The command word used with this question was 'Evaluate'. Evaluate requires a response that reviews the information provided then brings it together to form a conclusion. The indicative content provides examples of the sort of ideas candidate responses might address. It does not work as a points-based mark scheme.

Candidates were given several sources of information. Credit was given for the appropriate use of sources and for suitable conclusions. Better responses addressed several sources of information and included two or three substantial conclusions. Weaker responses focussed on one or two sources of information.

The graph shows the results of the second investigation.



Evaluate the role of the different STAT alleles in tuberculosis infections.

(9)

STAT alleles code for a gene that produces a transcription factor STAT3 - this regulates macrophages and T cells. The bases AA and TT on SNP1 and SNP2 respectively are associated with people with TB however AG and TC have no increased change as well as GG and CC. SNP1 AA and SNP2 TT are shown to have high association with percentage of people with TB. SNP2 TT is presents in 51% of people with Severe TB and 33% of those with mild TB. The error bars do not overlap meaning SNP2 TT has a significant impact on the severity of TB. Although SNP1 AA is associated with increased levels of TB (46% severe and 28% of mild TB patients have these allele bases) the standard deviations overlap. Therefore we cannot conclude SNP1 AA increases severity of TB in those with that base sequence.

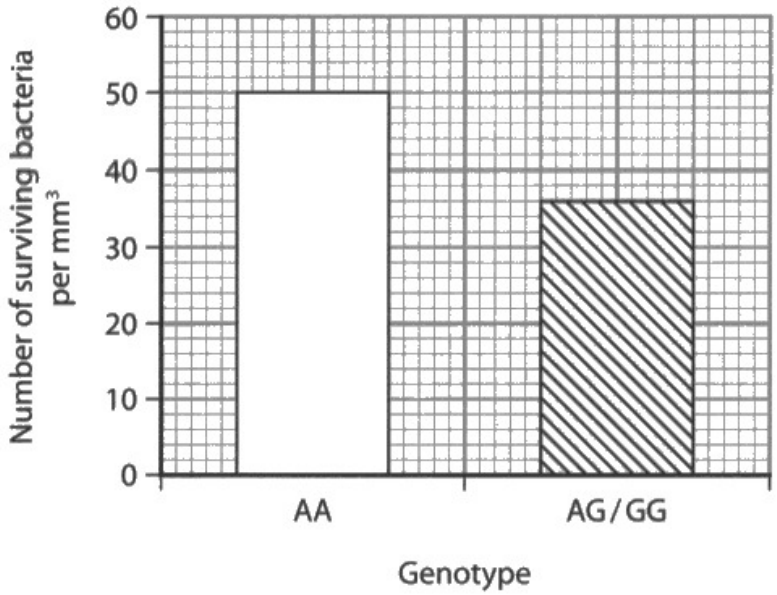
When grown with bacteria the white blood cells with the AA genotype had 14 more TB bacteria surviving per mm^3 compared to AA or GG. This suggests a reduced ability to kill bacteria and therefore an increased risk of TB with the AA genotype - Both SNP1 & SNP2 are in the introns of the STAT3 gene, so you would expect them to be removed during post transcriptional modification and not have much of an impact. However the alleles have a clear impact on risk of TB. The genotype of bases AA and TT may result in reduced transcription of the STAT3 gene. This reduces production of the transcription factor STAT3 and will reduce the ease of RNA polymerase binding to the promoter region of genes for macrophages and T cells. If these allele base combinations on the allele result in fewer macrophages and T cells, phagocytosis of the mycobacterium tuberculosis will be less efficient, and the specific immune response may be suppressed. This results in difficulty defending against a TB infection, therefore explaining the increased chance of TB, severe TB and ~~inability~~ reduced ability to kill bacteria once they have infected the body.

(Total for Question 7 = 12 marks)

ResultsPlus
Examiner Comments

This response was considered to be a good Level 3 response. The candidate has made use of all the information provided. The candidate has used their own biological knowledge and understanding to interpret the information and has made reasonable comments on error bars. There is little irrelevant information and the response is well organised.

The graph shows the results of the second investigation.



Evaluate the role of the different STAT alleles in tuberculosis infections.

(9)

The first table shows that ♀ with bases AA or TT present there is an increased chance of TB than in a healthy person, whereas the other bases show the same chance. This makes sence because A and T are complementary bases, so ~~one~~ will ~~combine~~ join together in double stranded DNA with hydrogen bonds. This shows that the STAT alleles at likely to be found at base A in SNP1 and base T in SNP2.

The first graph shows that SNP1 and 2 both cause higher % of patients with severe TB than mild, however with SNP1, the standard deviations of each box plot overlap, ~~suggesting~~ showing there is not a significant diffrence between % of cases with mild / severe TB., however in SNP2 they don't overlap, suggesting alleles for TT (SNP2) cause more severe TB infections.

The last graph shows that AA genotypes have a much higher AA number for surviving TB than AG/GG. This suggests that A is a recessive allele, so need two present in genotype to be expressed.

ResultsPlus
Examiner Comments

This response was considered to be a good Level 1 response. The candidate has attempted to use the table and both graphs. However, there are errors in interpretation as well as some misunderstanding of the information provided. There was no attempt at an overall interpretation of the data and little relevant application of biological knowledge and understanding.

Question 8 (a)

Many candidates produced a correct equation. Some candidates produced equations with an incorrect sign and a few gave the equation for the respiration of glucose. These candidates did not gain the mark.

8 The scientific article you have studied is adapted from a chapter in the book *Oxygen*.

Use the information from the scientific article and your own knowledge to answer the following questions.

(a) The mass of 'carbon turned into sugars by photosynthesis' is a measure of the gross productivity of photosynthetic organisms (paragraph 2).

Write an equation that describes the relationship between total carbon turned into sugar and the carbon turned into sugar that becomes available to primary consumers.

(1)

$6CO_2 + 6H_2O \xrightarrow{energy} C_6H_{12}O_6 + 6O_2$

ResultsPlus
Examiner Comments

A few candidates did not read the question carefully and produced equations for photosynthesis, such as in this example.

8 The scientific article you have studied is adapted from a chapter in the book *Oxygen*.

Use the information from the scientific article and your own knowledge to answer the following questions.

(a) The mass of 'carbon turned into sugars by photosynthesis' is a measure of the gross productivity of photosynthetic organisms (paragraph 2).

Write an equation that describes the relationship between total carbon turned into sugar and the carbon turned into sugar that becomes available to primary consumers.

(1)

8 NPP = GPP - R GPP = NPP - R

ResultsPlus
Examiner Comments

An incorrect equation that did not gain the mark.

ResultsPlus
Examiner Tip

What mistake has the candidate made? Look at the next example for a clue.

8 The scientific article you have studied is adapted from a chapter in the book *Oxygen*.

Use the information from the scientific article and your own knowledge to answer the following questions.

(a) The mass of 'carbon turned into sugars by photosynthesis' is a measure of the gross productivity of photosynthetic organisms (paragraph 2).

Write an equation that describes the relationship between total carbon turned into sugar and the carbon turned into sugar that becomes available to primary consumers.

(1)

NPP = GPP - R

ResultsPlus
Examiner Comments

This is a good example of a correct equation that gained the mark.

Question 8 (b)

The majority of candidates gave a correct answer. A common error was to suggest reduced NAD rather than reduced NADP. Some candidates used r or R as an abbreviation for reduced. R or r could stand for reduced or reducing, indicating different states for the NADP. The only abbreviations that candidates should use are those that are found in the specification.

(b) Name one product, other than ATP and oxygen, produced by the light dependent reactions of photosynthesis (paragraph 4).

(1)

NADH

ResultsPlus
Examiner Comments

The candidate did not gain the mark. A number of candidates made the same mistake, omitting the 'P'.

(b) Name one product, other than ATP and oxygen, produced by the light dependent reactions of photosynthesis (paragraph 4).

(1)

R. NADP

ResultsPlus
Examiner Comments

This response did not gain the mark as its unclear what R stands for. It could mean reducing or reduced.

ResultsPlus
Examiner Tip

Only use abbreviations that are found in the specification. Other abbreviations can be open to misinterpretation and prevent the award of a mark. Does R.NADP stand for reducing or reduced NADP? The examiner doesn't know what you want R to stand for and can't decide on your behalf.

Question 8 (c)

Many candidates struggled to provide a complete answer for this question. Many simply described the uses for ATP. These candidates often only gained one mark (Mark Point 3). Candidates that made a better attempt at an answer usually described hydrolysis of ATP releasing energy (Mark Point 2) and often referred to ATP being an immediate source of energy (Mark Point 4). Fewer candidates referred to phosphate bonds (Mark Point 1).

(c) Explain why cells use 'chemical energy in the form of ATP' (paragraphs 4 and 5).

(3)

The hydrolysis of ATP into ADP and Pi allows a quick and effective release of energy as it is compact, easy to transport, and easy to store. They use it in photosynthesis to phosphorylate GP to GALP for the production of glucose and regeneration of RUBP

ATP is also easy to ~~regulate~~ regenerate via respiration, so it is a renewable energy source.

ResultsPlus
Examiner Comments

For this response, Mark Point 2 and Mark Point 4 were awarded for the first two lines. Mark Point 3 was then awarded for lines 4 to 6.

Question 8 (d)

Complete responses were provided by many candidates and all five marking points were frequently seen. Some candidates mixed up GP and GALP (and did not gain Mark Point 3 or Mark Point 4) and some forgot to attribute the involvement of reduced NADP and ATP in the conversion of GP to GALP which was required for Mark Point 4.

(d) Describe how 'plant photosynthesis converts carbon dioxide from the air into simple organic molecules' (paragraph 5).

(4)

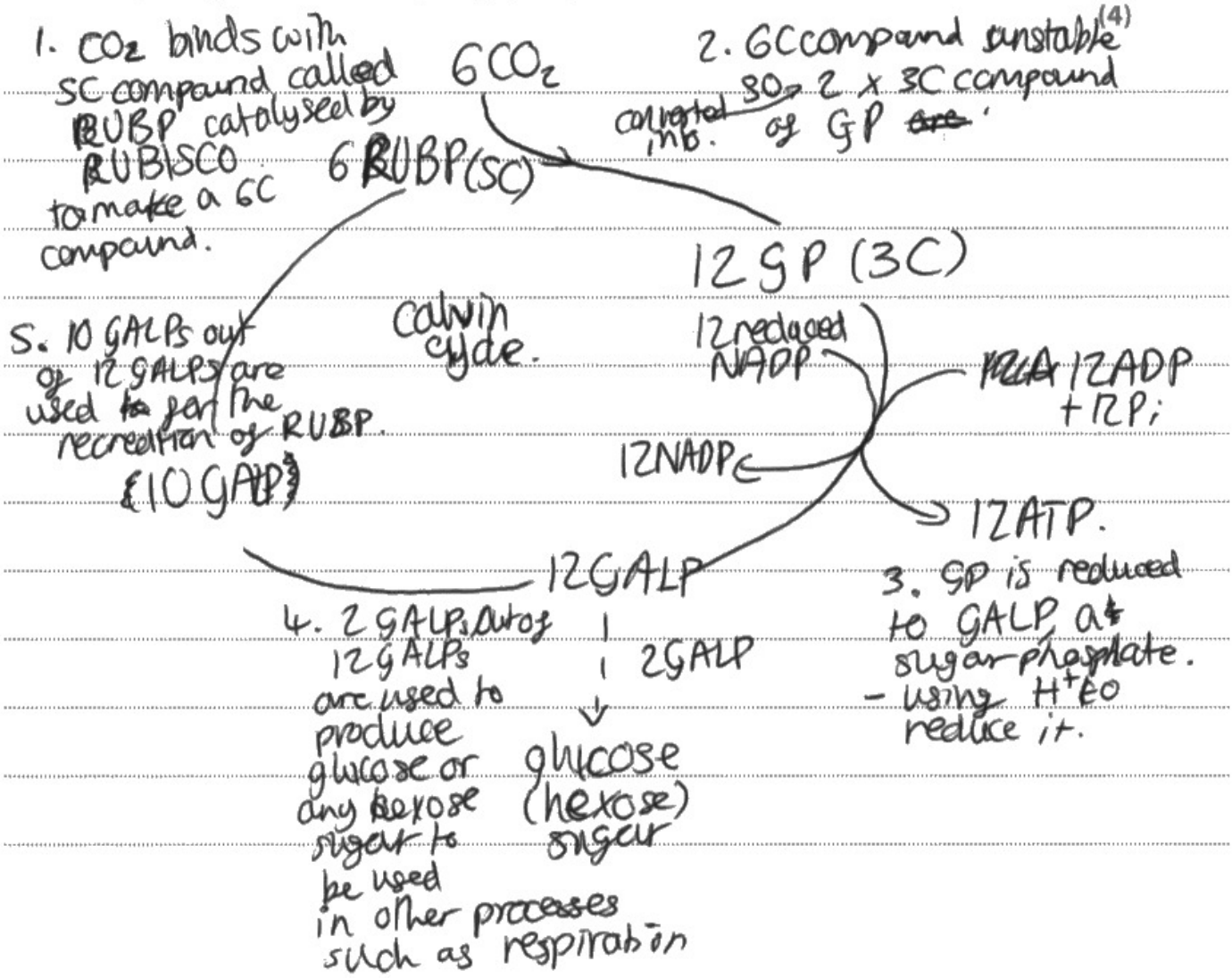
- via the calvin cycle.
- ~~carbon~~ CO_2 combines with RuBP ~~with~~ to form 2x 3 carbon GP molecules. this reaction is catalysed by the enzyme rubisco.
- GP is converted into GALP using the products of the light dependent reaction (ATP and NADPH)
- some GALP can be ~~as~~ recycled back into RuBP but some is used to form organic molecules such as glucose which would then join together in a condensation reaction to produce starch by ~~glycosidic~~ formation of glycosidic bonds (amylose and amylopectin)

ResultsPlus
Examiner Comments

This response gained a maximum of four marks. All five marking points were seen, Mark Point 1 (line 2), Mark Point 3 (lines 2 and 3), Mark Point 2 (line 4), Mark Point 4 (lines 5 and 6) and Mark Point 5 (line 8).

(d) Describe how 'plant photosynthesis converts carbon dioxide from the air into simple organic molecules' (paragraph 5).

(4)



ResultsPlus
Examiner Comments

This is an example of a response in which the candidate produced an annotated diagram that gained full marks.

ResultsPlus
Examiner Tip

If you use a diagram to help answer a question, make sure you annotate the diagram with relevant details. This is a good example. The diagram by itself is probably not sufficient for some of the marking points. However, with the annotations it clearly answers the question well and gains full marks.

Question 8 (e)

Many candidates recognised that they needed to devise an investigation using chloroplasts (Mark Point 1). These candidates often went on to gain Mark Point 3 and Mark Point 4. Some went on to describe collecting, and occasionally, the testing of the gas produced (Mark Point 5). Mark Point 5 was also awarded if candidates described observing the decolourisation of DCPIP rather than the collection and testing of the gas produced.

A number of candidates described in great detail the preparation of chloroplasts, which was not required. Some candidates suggested experiments using radioactivity. The use of water containing isotopes of oxygen (or radioactive oxygen) were accepted for Mark Point 2. A number of candidates did not recognise they were being asked to devise an investigation using chloroplasts. These candidates suggested investigations using plants and generally gained Mark Point 3 only.

(e) Devise an investigation to show that in chloroplasts, the oxygen for photosynthesis comes from water and not carbon dioxide (paragraphs 6 and 7).

(4)

$Fe(CN_4)_4^{+2}$

Isolate chloroplast using crushed spinach leaves added to 0.5M of cold isolation solution. Centrifuge for 10 minutes and remove the top aquoes solution. ~~The~~ To the chloroplast pellets at the bottom add more cold isolation solution and store it in ice coater. Close the bung of a test tube connected to a delivery tube. Use an inverted measuring cylinder submerged in coater. Place the test tube coith isolation solution in a lamps light for 20 minutes and collect gas produced after adding iron ferricyanide into the solution. Test the gas for oxygen to prove that CO_2 ~~is~~ was not the source of oxygen.

ResultsPlus
Examiner Comments

This response gained four marks. Mark Point 1 in line 1, Mark Point 4 in line 11. Mark Point 2 was awarded in line 12 and 13. Finally, Mark Point 5 was awarded for lines 7 to 9 together with the last three lines.

ResultsPlus
Examiner Tip

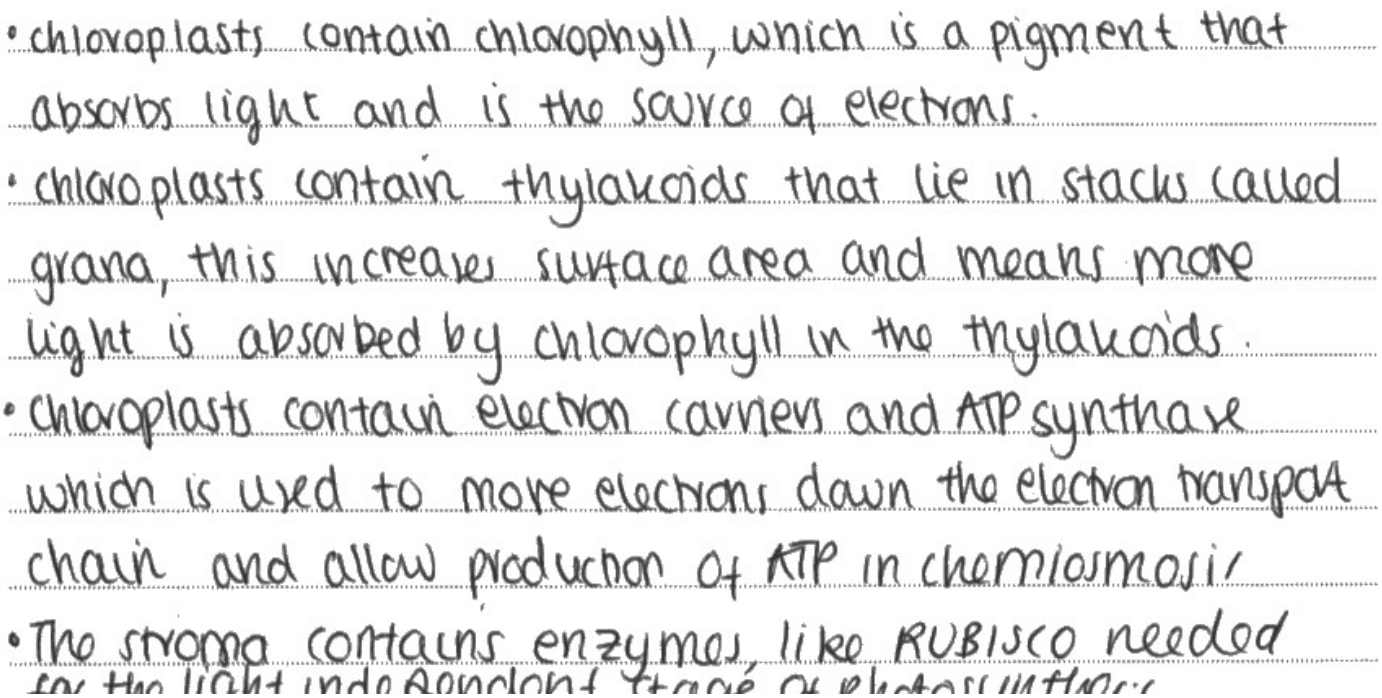
When devising experiments based on core practicals think carefully about the information that is required. When answering this question many candidates gave detailed descriptions of how they would isolate chloroplasts. Often these descriptions filled the answer space leaving candidates struggling to fit in the rest of their answer.

Question 8 (f)

A surprising number of candidates struggled to explain the adaptations of chloroplasts. Many simply described features of chloroplasts. Mark Point 1 and Mark Point 2 were frequently seen. However, many candidates did not gain Mark Point 2 because they failed to link photosynthetic pigments to its role in absorbing light.

(f) Explain how chloroplasts are adapted for their role in photosynthesis (paragraphs 9 and 10).

(4)



ResultsPlus
Examiner Comments

This response gained all four available marks. Mark Point 1 and 2 for the first four lines, Mark Point 3 lines 6 to 8 and Mark Point 4 for the last two lines.

Question 8 (g)

This question was answered well by many candidates. All five marking points were frequently seen. Mark Point 3 was lost when candidates described protons being pumped into the intermembrane space rather than into the thylakoid space. Some candidates used the terms pump and diffuse in the wrong context and failed to gain Mark Point 3 or 4.

(g) Explain how energy of the electrons passed along an electron transport chain 'is used to power the synthesis of ATP' (paragraph 10).

(3)

Electrons pass along the electron transport chain via redox reactions. The proteins are reduced when the electron arrives and oxidised when passed on. During this process, the electrons lose energy as they go. This is used to pump protons into the intermembrane space, forming a concentration gradient. Then, the protons move down the concentration gradient via ATP synthase. This allows ATP to be formed from ADP and inorganic phosphate. The movement of protons is called chemiosmosis.

ResultsPlus
Examiner Comments

This response gained three marks. Mark Point 2 (lines 1 to 3), Mark Point 4 (line 5 and 6) and Mark Point 5 (lines 6 and 7).

This response would not have gained Mark Point 3 as the candidate confused mitochondria and chloroplasts and described electrons being pumped into the intermembrane space rather than into the thylakoid lumen.

Question 8 (h)

Many candidates struggled to provide complete answers to this question. A number of candidates appeared to not appreciate that chlorophyll was not a protein and gave detailed accounts of mutations, changes to primary structure and even suggested changes in the shape of an active site. Mark Point 1 was the mark most frequently awarded. Candidates believing that chlorophyll is a protein were allowed Mark Point 1. Mark Point 2 and 3 were infrequently seen.

(h) Explain how 'tiny changes' in chlorophyll molecules could result in a change in the wavelength of light absorbed (paragraphs 12 and 13).

(3)

The structure of chlorophyll determines the ~~by~~ types of wavelength it can absorb. Chlorophyll is a large molecule with a protein component, so a small change in its ~~a~~ amino acid sequence can change the tertiary structure ~~as~~ and thus the the wavelength it can absorb to excite electons. This also depends on energy levels of electron orbitals.

ResultsPlus
Examiner Comments

This example gained two marks. Although the candidate has the misconception that chlorophyll is a protein this was ignored and Mark Point 1 was allowed for a change in tertiary structure. Mark Point 3 was then awarded for lines 6 and 7.

Question 8 (i)

Many candidates gained two or three of the available marks. Mark Point 1, 2 and 4 were frequently observed. Mark Point 4 was usually awarded for the additional guidance accepting a description of the more similar the sequence the more likely one evolved from the other.

Very few candidates addressed the idea of looking at organisms at different stages in evolution (Mark Point 3) or the preferred answer for Mark Point 4. A number of candidates produced answers in terms of gene mutations and natural selection.

(i) The structure of the oxygen-evolving complex is similar to that of catalase, 'it looks as if it evolved from two catalase enzymes lashed together' (paragraph 17).

Explain how proteomics and genomics could be used to support the suggestion that the oxygen-evolving complex evolved from catalase.

(4)

Study the sequence of amino acids and base sequences of the gene that codes for protein. Compare these sequences. The more similarities the closer related the two are and it is likely that the oxygen evolving complex has evolved from catalase.

Can work back if know the mutation frequency to guess the time the ~~OEC~~ OE complex started evolving.

ResultsPlus
Examiner Comments

This is a fairly typical response that gained three marks. Mark Point 1 and 2 were awarded for the first three lines and Mark Point 4 for lines 4 to 6.

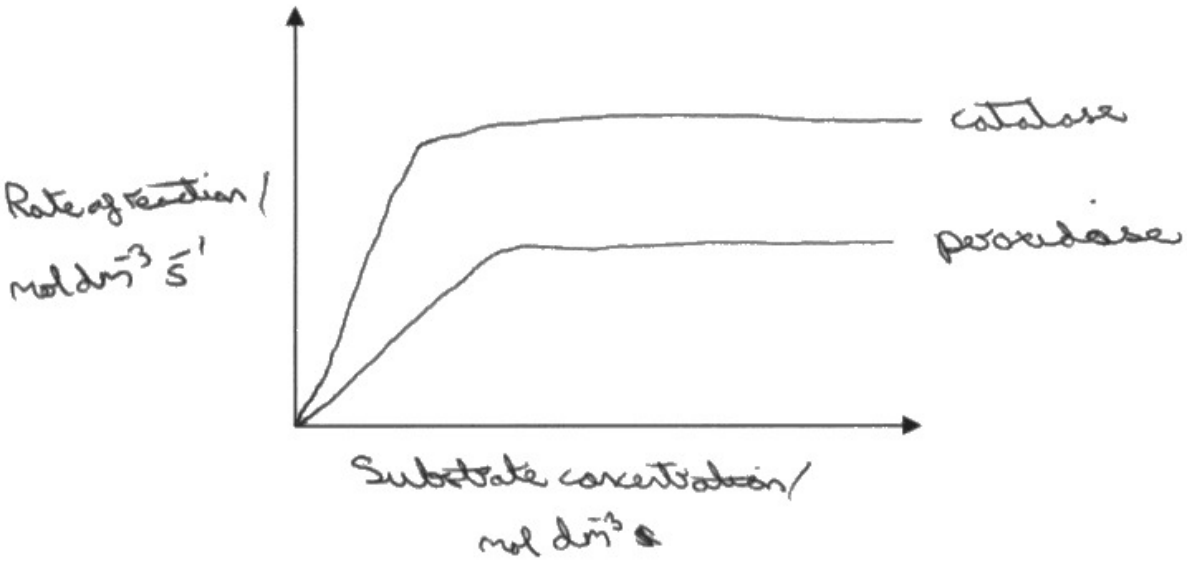
Question 8 (j)

Many candidates struggled to provide complete answers to this question. A surprising number of candidates sketched a single line and did not gain Mark Point 1. Marking point 2 was frequently awarded, however a number of candidates put the independent variable on the x-axis and so did not gain this mark. Many candidates struggled to suggest suitable units (Mark Point 3) even with the acceptance of minor errors in units and less than ideal units such as s^{-1}.

(j) Sketch a graph to compare the effect of substrate concentration on the rate of reaction of catalase and peroxidase (paragraphs 19 and 20).

Include suitable units in the labels for each axis.

(3)



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Examiner Comments

This response gained all three available marks.

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Examiner Tip

When you undertake core practicals make sure you understand the way the data can be presented. For graphs think carefully about what the axis represents including labels and units.

Paper Summary

Based on their performance on this paper, candidates should:

- Be prepared to apply what you have learnt from core practicals to answer questions in the exam.
- Read all the information provided – especially where the stimulus material is unfamiliar.
- Read the whole question and identify the command word and the context.
- Set out calculations carefully – show each stage of your working, in case a mistake is made at the final step.
- Attempt every question – time permitting, read the stem of the question carefully as there is often helpful information in there that might help.
- Add specific, precise details – do not expect the examiners to fill in the gaps for you.
- Use bullet points if it helps you organise your answers to questions – but make sure the statements contain details and are not too brief.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

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