

PEARSON EDEXCEL A-LEVEL BIOLOGY A • 9BN0

# BIOLOGY



**EXAM QUESTION PACK**

**TOPIC 8: GREY MATTER**

**SCORE**

**/582**

**PERCENTAGE**

**%**

**STEMUP**

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Q1.

Visual development requires exposure of the visual cortex to environmental signals during a critical period.

Describe the role of visual stimulation on the development of the visual cortex during the critical period.

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**(Total for question = 3 marks)**

Q2.

Voltage-gated  $K^+$  and  $Na^+$  channels are involved in the transmission of impulses in sensory and motor neurones.

Describe the differences in the structure of a myelinated sensory neurone and a myelinated motor neurone.

(3)

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Q3.

A person arrived at hospital having eaten some poisonous berries.

An electrocardiogram (ECG) was recorded for this person.

The poison also caused the pupils of this person to dilate.

Describe the interaction of the muscles in the eye that led to this dilation of the pupils.

(3)

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**(Total for question = 3 marks)**

Q4.

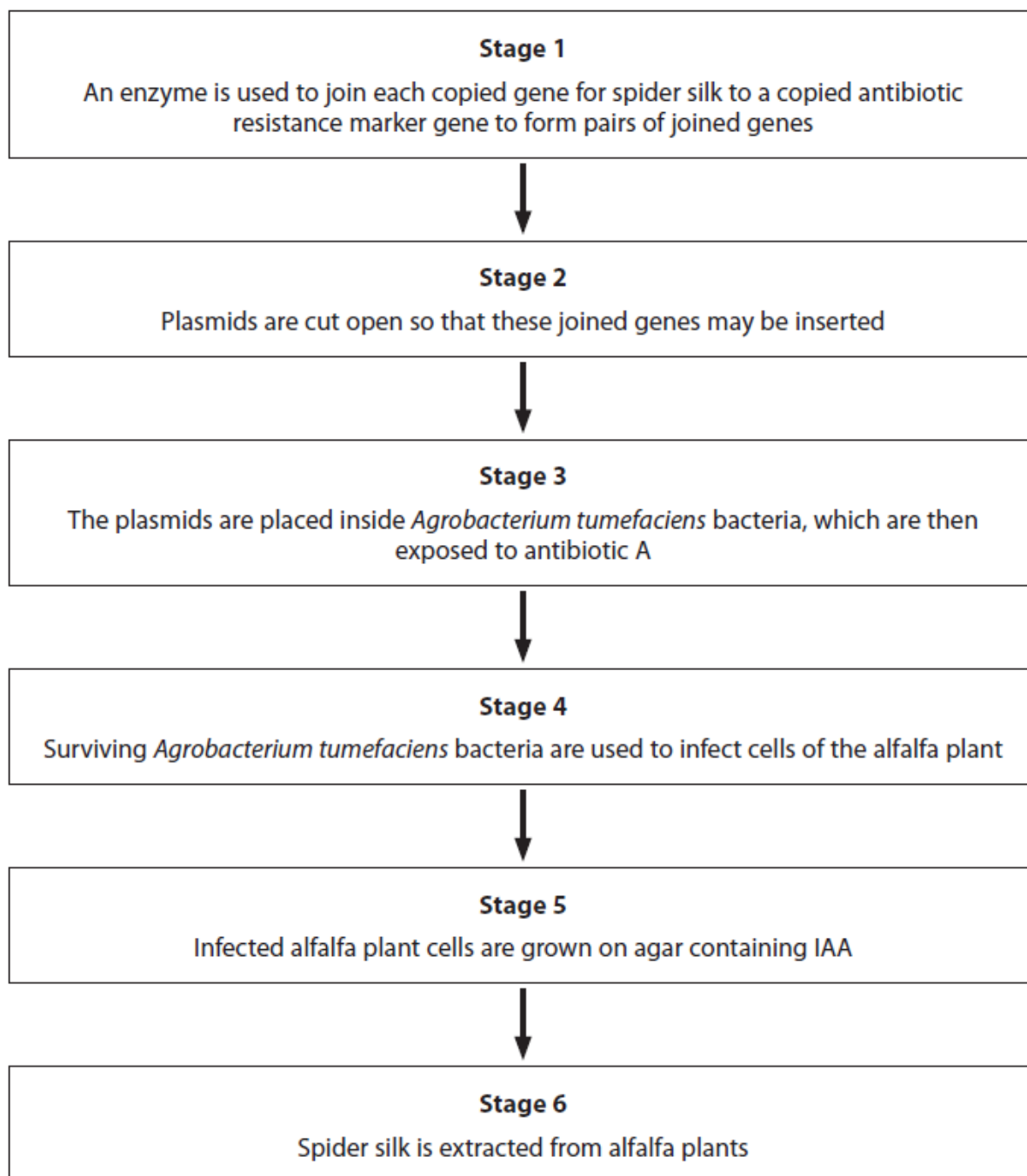
**Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

Spider silk is a very strong and flexible natural fibre. It is of interest to humans as a possible fibre for protective clothing.

Scientists have genetically modified a range of organisms to produce spider silk, including goats and plants such as alfalfa.

A gene for spider silk is copied. A gene for resistance to antibiotic A is also copied.

The flow diagram shows some of the stages in genetically modifying alfalfa plants to produce spider silk using the copied genes.



(i) Explain how an enzyme is involved in joining the two different genes together in stage 1.

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(ii) Which one of the following enzymes can be used to cut open the plasmids in stage 2?

(1)

- ☐ **A** DNA polymerase
- ☐ **B** RNA ligase
- ☐ **C** RNA polymerase
- ☐ **D** restriction endonuclease

(iii) Explain why antibiotic A is used in stage 3.

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(iv) Give reasons why the infected alfalfa plant cells are grown on agar containing IAA in stage 5.

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(v) The table shows the mass of spider silk produced from the genetically modified alfalfa in stage 6. It also shows the mass of spider silk produced from the genetically modified goats.

| Organism | Mass of spider silk produced per year |
|----------|---------------------------------------|
| Alfalfa  | 218 kg per acre                       |
| Goat     | 10 kg per goat                        |

A typical number of goats that can be kept on one acre of land is 12.

Calculate the percentage increase in spider silk produced by the alfalfa plants compared with the goats.

(3)

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**(Total for question = 11 marks)**

Q5.

Serotonin is found in the brain and is important in health and wellbeing.

An imbalance of serotonin can lead to problems such as depression. An individual with symptoms of depression may have low serotonin levels in the brain.

The use of drugs such as MDMA (ecstasy) can cause an imbalance of chemicals in the brain.

(i) Describe how the use of MDMA could affect the transmission of impulses in the brain.

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(ii) Individuals who use MDMA may develop the symptoms of depression.

Explain how the use of MDMA could result in the development of these symptoms.

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**(Total for question = 4 marks)**

Q6.

A study was carried out to investigate the effect of red light and far red light on the growth of flowers in a plant.

Plants were kept under two different light regimes, A and B. Regime A used red light and far red light at the same intensity. Regime B used red light and far red light but the red light was at a lower intensity. The intensity of the far red light was unchanged.

When the plants were fully grown, the dry mass of the flowers produced was measured.

This study was repeated using a new group of plants.

The results for the original study and the repeat study are shown in the table.

| Study    | Mean dry mass of the flowers / g |          |
|----------|----------------------------------|----------|
|          | Regime A                         | Regime B |
| Original | 58                               | 45       |
| Repeat   | 43                               | 38       |

(i) Calculate the percentage difference between the mean dry mass of flowers in regime A with that in regime B in the original study.

(2)

Answer .....

(ii) Compare and contrast the results of regime A with regime B for both the original and repeat studies.

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**(Total for question = 4 marks)**

Q7.

The ability to grow long stems is important in woodland plants because longer stems increase the chance of the plant receiving light for photosynthesis.

Any plant in the shade of other plants will be exposed to more far red light than red light because other plants absorb most of the red light.

A student wrote the hypothesis:

*'The length of a plant stem depends on the amount of red light or far red light they receive'.*

Design an investigation the student could use to test this hypothesis.

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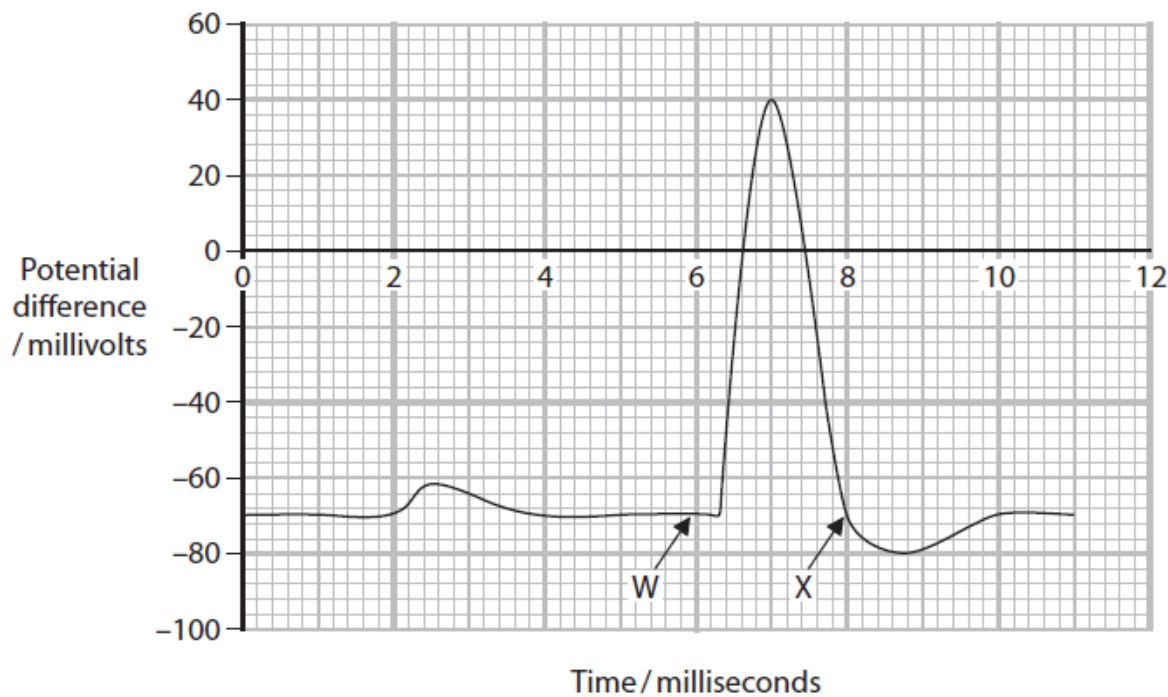
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(Total for question = 4 marks)

Q8.

The nervous system is one of the features found only in animals.

The graph shows the change in potential difference across the cell surface membrane of a neurone when it is stimulated at point W.



(i) The threshold intensity is the minimum electrical stimulus that will cause a neurone to form an action potential.

Which potential difference could be the threshold potential for this neurone?

☒ **A** -80 millivolts

- ☐ **B** -70 millivolts
- ☐ **C** -60 millivolts
- ☐ **D** 40 millivolts

(ii) Explain the changes in the sodium and potassium ion concentrations in the cytoplasm of the neurone from point W to point X on the graph.

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(iii) Explain why the neurone becomes hyperpolarised after point X on the graph.

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**(Total for question = 7 marks)**

Q9.

The scientific article you have studied is from *Scientific American*.

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

The immune system plays a role in recovery following spinal cord injuries.

Give **two** ethical arguments to support the use of rats and mice with spinal cord injuries in these experiments (paragraph 10).

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**(Total for question = 2 marks)**

Q10.

The scientific article you have studied is adapted from *Scientific American*.

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

Discuss the ethical issues relating to the use of mice in experiments such as those described in the article (paragraph 25).

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**(Total for question = 4 marks)**

Q11.

Some marine snails produce chemicals called conotoxins. These chemicals paralyse the prey of these snails by interfering with the conduction of nerve impulses to muscles.

Conotoxins can be modified to produce painkillers.

The effects of conotoxins on the nervous system were first demonstrated in experiments involving animals.

These experiments were involved in the development of painkillers from conotoxins.

(i) Describe the ethical issues concerning the use of animals in this research.

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(ii) After testing on animals, painkillers undergo three-phased testing.

In an investigation testing the effectiveness of a painkiller produced from conotoxin, the new painkiller was tested on a group of healthy volunteers.

Explain the reasons for this stage in the testing of the painkiller.

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Q12.

The modern bread wheat plant (*Triticum aestivum*) has been developed from other plant species that have different genomes.

Three species of plant and their genomes are shown in the images.



*Triticum aestivum*  
Genomes A, B and D

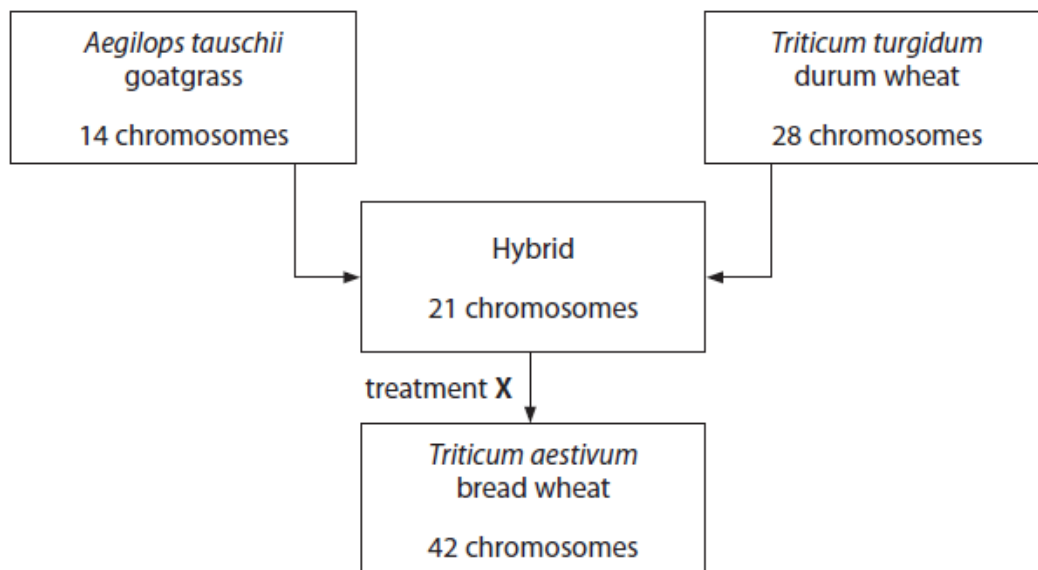


*Triticum turgidum*  
Genomes A and B



*Aegilops tauschii*  
Genome D

The diagram shows how chromosomes from different species have combined to produce the bread wheat species used to produce flour.



\* New varieties of plants with desirable combinations of characteristics can be produced using the methods shown in the table.

| Method               | Example                                                                                                                      |
|----------------------|------------------------------------------------------------------------------------------------------------------------------|
| Formation of hybrids | In wheat, genome D includes genes for a tolerance of harsh conditions and genome A promotes large starch stores in seeds.    |
| Genetic modification | Production of specific molecules in plant cells.                                                                             |
| Selective breeding   | Plants with desired characteristics can be used for breeding to produce plants with combinations of desired characteristics. |

Evaluate the risks and benefits of producing varieties of plants using these methods.

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**(Total for question = 6 marks)**

Q13.

The scientific article you have studied is adapted from articles from Nature, Scientific American and the ScienceDaily website.

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

(a) Give the name of the 'simpler molecules' produced by the breakdown of glucose that can enter the mitochondria (paragraph 3).

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(b) (i) Describe the role of oxygen in the 'last reaction' involved in aerobic respiration in the mitochondria (paragraph 3).

**(1)**

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(ii) Explain how carbon monoxide reduces the production of ATP in the electron transport chain (paragraphs 3 and 4).

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(c) Explain how nitric oxide (NO) released by nerve endings could result in vasoconstriction of blood vessels (paragraphs 7 and 9).

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(d) Explain how free radicals may be involved in the production of P53 in the cell (paragraph 17).

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(e) Describe **three** structural differences between the inner mitochondrial membrane and the outer mitochondrial membrane (paragraphs 18 and 19).

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(f) Long wavelengths of light, in the near infrared (NIR) spectrum, appear to be able to modulate

cell respiration by affecting cytochrome oxidase (paragraph 30).

Deduce how this may explain why NIR phototherapy has 'shown promise' in reducing cell death caused by myocardial infarction (paragraph 34).

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(g) (i) Describe how scientists could have produced 'genetically modified neurons' described in paragraphs 38 and 39.

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(ii) A light sensitive protein is channelrhodopsin-2. This is a channel protein that spans membranes. When exposed to blue light these channel proteins open and allow sodium ions to flow through.

Explain how a brief flash of light could cause neurotransmitter to be released by 'the genetically modified neurons' (paragraphs 38 and 39).

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(h) Explain how fMRI allowed Vandewalle to make the observations described in paragraph 50.

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**(Total for question = 30 marks)**

Q14.

The muscles of the earthworm (*Lumbricus terrestris*) contract when it is touched. This is known as the withdrawal response.

Contraction of the muscle in the withdrawal response is stimulated by nerve impulses. These nerve impulses can be detected using electrodes.

Explain the electrical changes in an axon that allow these nerve impulses to be detected.

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**(Total for question = 4 marks)**

Q15.

Glucosaminoglycans (GAGs) are the by-products of chemical reactions inside cells. GAGs are broken down by enzymes inside lysosomes in cells.

Mucopolysaccharidosis type I (MPS I) is a genetic condition that results in the build-up of GAGs inside cells.

MPS I affects the production of enzyme G that breaks down GAGs inside lysosomes.

More than 50 different mutations in the gene for enzyme G have been found to result in MPS I. Most of these mutations involve changing a single base in the gene.

(i) Explain how a single base mutation can lead to an altered primary structure of enzyme G.

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(ii) Explain how human genome sequencing can be used to identify the mutations associated with MPS I.

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(Total for question = 6 marks)

Q16.

People with Guillain-Barré syndrome (GBS) suffer from a rapid onset of muscle weakness. It is thought that GBS is caused by damage to the peripheral nervous system.

In individuals with GBS, the immune system attacks and destroys the myelin sheath surrounding some neurones.

Neurone conduction was studied in an individual with GBS and in an individual without GBS. The results are shown in the table.

| Individual  | Sensory neurone                         |                               | Motor neurone                           |                               |
|-------------|-----------------------------------------|-------------------------------|-----------------------------------------|-------------------------------|
|             | Speed of conduction / metres per second | Size of action potential / mV | Speed of conduction / metres per second | Size of action potential / mV |
| With GBS    | 54                                      | 35                            | 39                                      | 10                            |
| Without GBS | 58                                      | 33                            | 63                                      | 10                            |

Explain why GBS caused muscle weakness in this individual.

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**(Total for question = 4 marks)**

Q17.

The scientific article you have studied is adapted from several sources.

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

Explain why genetically modified bacteria delivering drugs 'to the exact tissue in the body where they're needed and nowhere else' would decrease side effects (paragraph 34).

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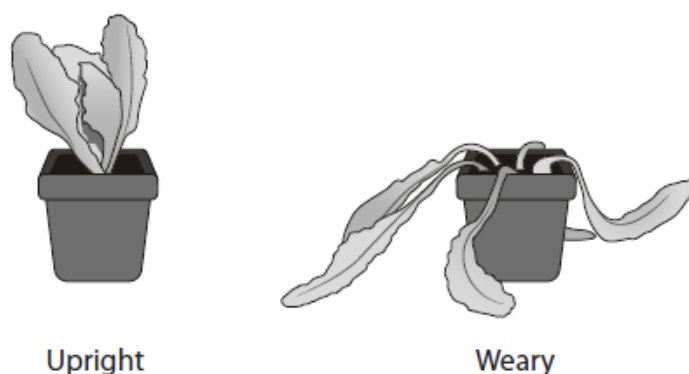
**(Total for question = 2 marks)**

Q18.

Lettuce plants usually grow upright. This is the 'upright' phenotype.

In one variety of lettuce the stem of the lettuce grows along the ground. This is the 'weary' phenotype.

These two phenotypes are shown in the diagram.



The effect of gravity on the growth of lettuce plants with either upright or weary phenotype was investigated.

The diagram shows the stages in this investigation.

|                       |                                                                                                                                   |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Stage A</b></p> | <p>Lettuce plants were grown until their stems were 15 cm long.</p>                                                               |
| <p><b>Stage B</b></p> | <p>The lettuce plants were then placed in complete darkness and rotated so that they were at 90° to the direction of gravity.</p> |
| <p><b>Stage C</b></p> | <p>The curvatures of the stems (<math>\alpha</math>) and roots (<math>\theta</math>) were measured for the next 23 days.</p>      |

(i) Explain why the plants were placed in a box in complete darkness.

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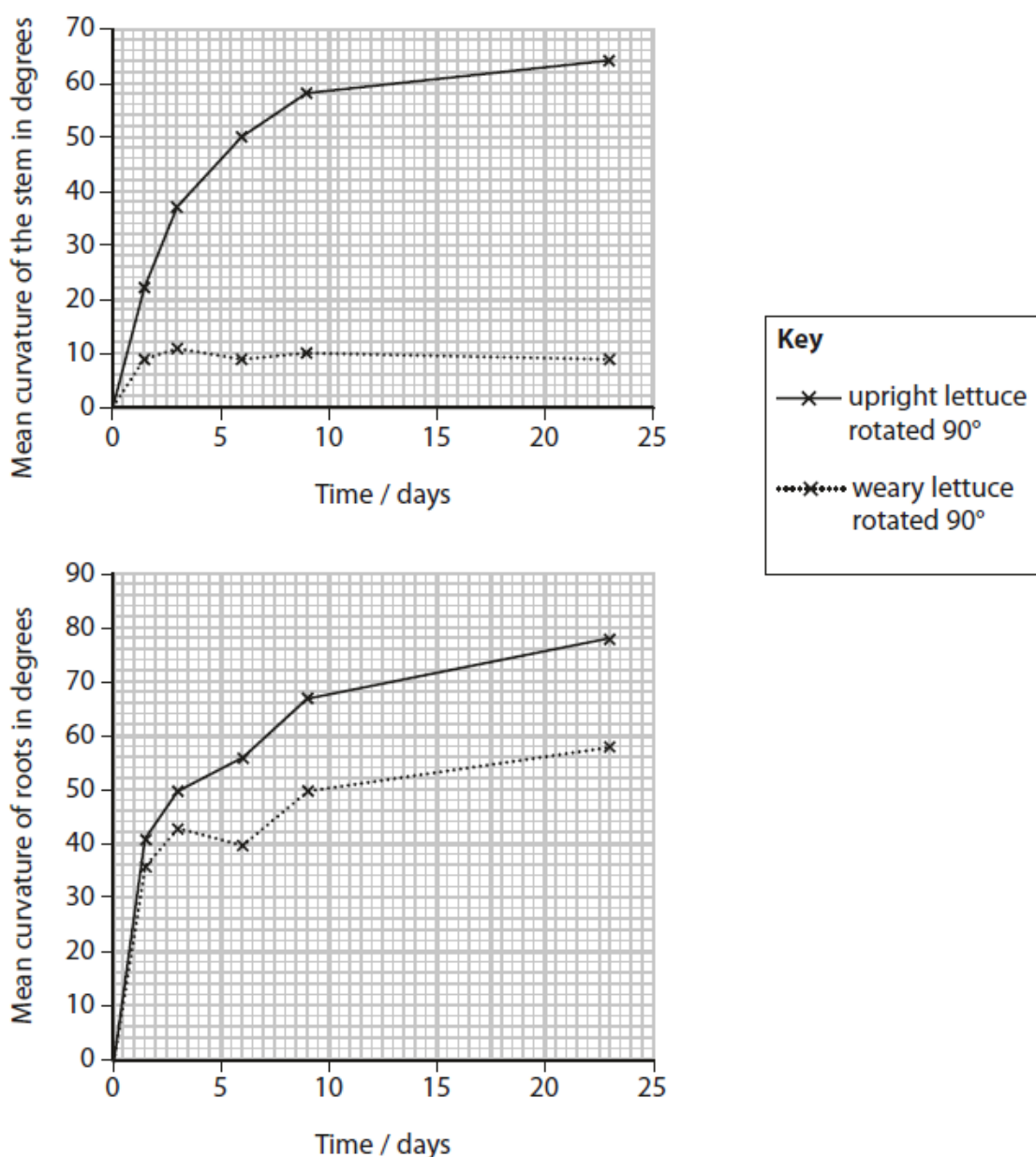
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(ii) The mean curvatures of the stems and the roots are shown in the graphs.



Calculate the difference in the mean rate of curvature of the stems and roots of the weary lettuce plants over 23 days.

(2)

Answer .....

(iii) Explain why the stems of weary lettuce do not respond to gravity.

(2)

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**(Total for question = 7 marks)**

Q19.

Habituation is a learning response observed in many types of animal.

Scientists are using fruit fly habituation to investigate the role of genes associated with human autism spectrum disorders (ASD).

Before they can do this, the scientists first identify genes linked to human ASD.

Describe how genes linked to human ASD could be identified.

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**(Total for question = 2 marks)**

Q20.

The human brain is an organ that has a range of functions.

A student produced a table linking three descriptions of brain function to a labelled diagram of the brain.

| Label | Description of function of labelled region in brain                                         |
|-------|---------------------------------------------------------------------------------------------|
| 1     | Site where more synapses are formed during the critical window for vision                   |
| 2     | Required for the fine motor skills to draw a straight line                                  |
| 3     | Area that sends impulses to the sinoatrial node (SAN) in response to a lowering of blood pH |

Which diagram of the brain correctly matches the table?

(1)

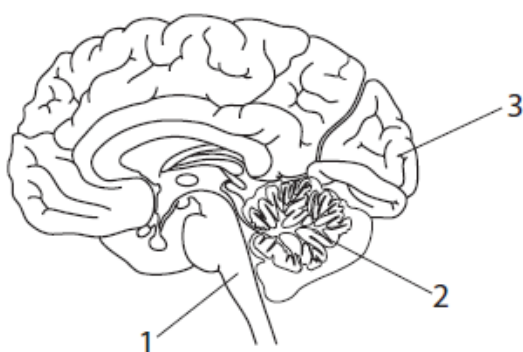


Diagram A

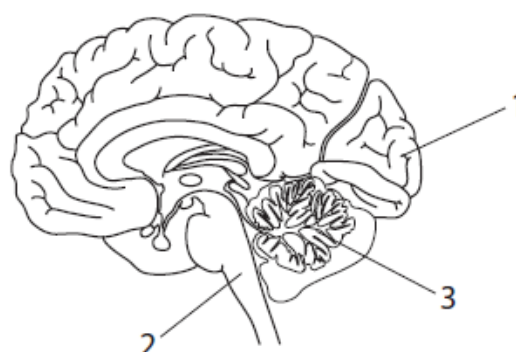


Diagram B

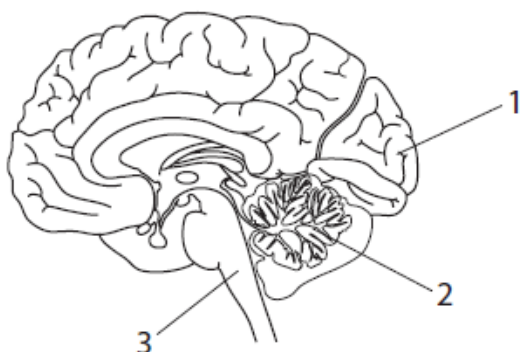


Diagram C

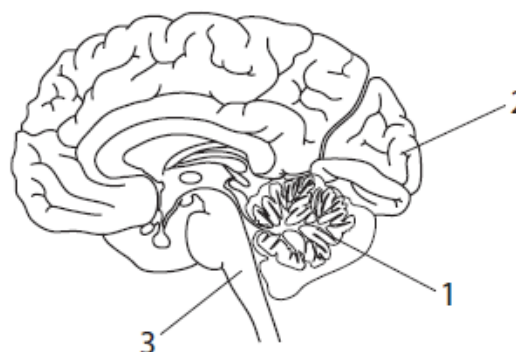


Diagram D



Q21.

The human brain is an organ that has a range of functions.

There are various types of scan that can be used to study the brain.

(i) Describe why a region of the brain might appear lighter in an image obtained by a functional magnetic resonance image (fMRI) scan.

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(ii) One scan combines positron emission tomography (PET) and computed tomography (CT). This scan can be used to show whether a person has cancer.

Describe why a combined PET and CT scan may be better for diagnosing cancer than a PET or CT scan on its own.

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**(Total for question = 6 marks)**

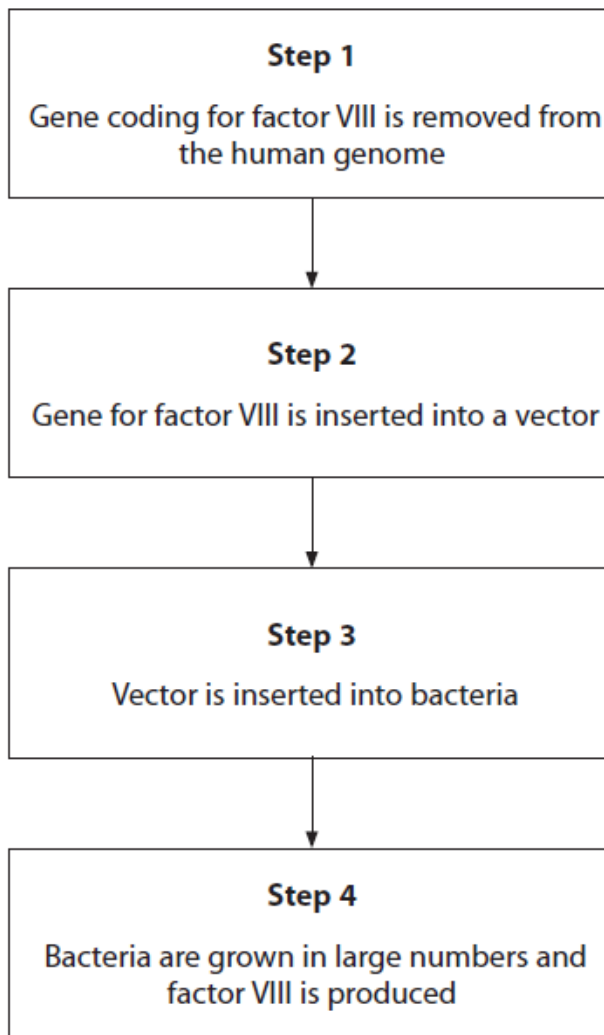
Q22.

Haemophilia is a genetic disorder where blood does not clot normally.

It can be treated by injecting factor VIII, a protein involved in the blood-clotting process that is not produced by people with haemophilia type A.

Bacteria can be genetically modified to produce factor VIII.

(a) The diagram shows some of the steps involved in genetically modifying bacteria to produce factor VIII.



(i) Describe the difference between a gene and the genome

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(ii) Give the name of the type of enzyme that would be used to insert the gene into the DNA of the vector at Step 2.

(1)

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(iii) Give an example of a suitable vector that would be used in Step 2 or 3.

(1)

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(iv) Describe how the genetically modified bacteria would use the gene from the human genome to produced factor VIII in Step 4.

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(b) Factor VIII is required for the activation of prothrombin.

Explain why the blood-clotting process does not take place normally when a person with haemophilia type A cuts their hand.

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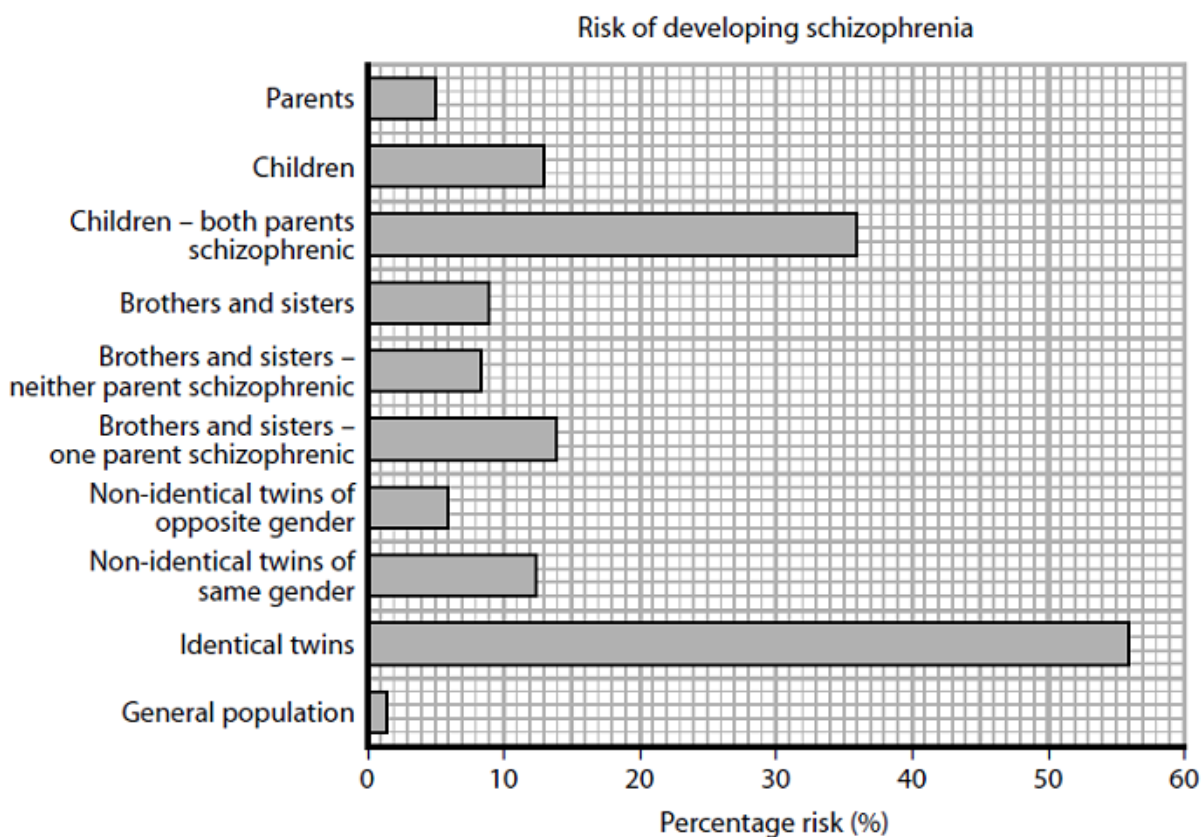
**(Total for question = 9 marks)**

Q23.

Schizophrenia is a disorder that affects brain structure and function and has a variety of symptoms.

The bar graph shows how the relationship to a family member suffering from schizophrenia affects the risk that the individual will also develop schizophrenia.

The percentage risk of schizophrenia in the general population is included for comparison.



(a) Explain the difference between the percentage risks of developing schizophrenia in identical twins and non-identical twins of the same gender.

(2)

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(b) Some early studies of schizophrenia included identical twins raised in separate families.

(i) Explain how the design of these studies allows the influence of environmental factors on the development of schizophrenia to be investigated.

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(ii) The conclusions based on these early studies of identical twins raised in separate families are said to lack validity.

Give **two** reasons why these studies may lack validity.

(2)

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(c) Schizophrenia has been linked to abnormally high levels of a neurotransmitter in the brain.

Explain how the action of the drugs used to treat schizophrenia may lead some patients to experience symptoms similar to those of Parkinson's disease.

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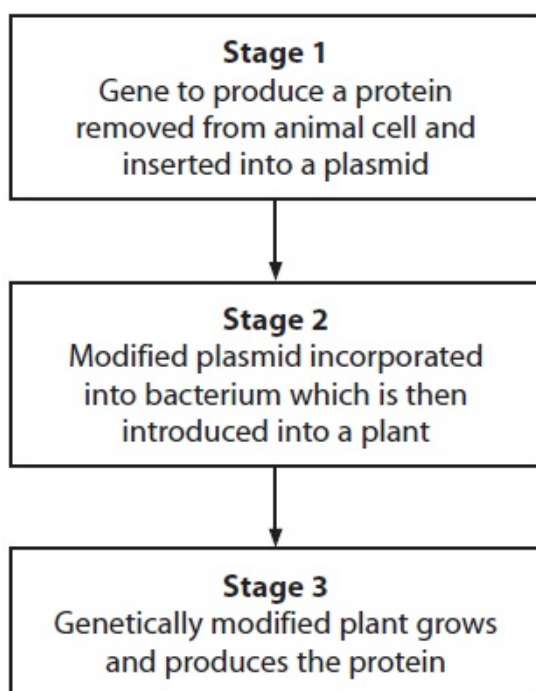
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**(Total for question = 11 marks)**

Some organisms have been genetically modified to produce proteins including hormones and vaccines.

The flow diagram below shows part of a process to produce a protein, using genetically modified plants.



(a) Describe and explain the role of the enzymes involved in stage 1.

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(b) Describe the structure of the modified plasmid used in stage 2.

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(c) Suggest why plants rather than bacteria are used to produce the protein in stage 3.

(2)

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(d) Describe **two** risks associated with the use of genetically modified organisms.

(2)

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**(Total for question = 11 marks)**

Q25.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

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

State what is meant by the genome of a thermophile (paragraph 14). (1)

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(Total for question = 1 mark)

**Mark Scheme**

Q1.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Additional Guidance                                                                                                                                     | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"><li>• ocular dominance columns (develop in visual cortex) (1)</li><li>• neurones form synapses with these { cells / columns } (1)</li><li>• { stimuli / action potentials / impulses } along neurones required to strengthen connections (with cells of ocular dominance columns)</li><li>• stimulation during the critical period is needed to form (effective) connections in the visual cortex</li></ul> | <p>ALLOW columns of (target) cells</p> <p>ALLOW more synapses for stronger connections<br/>OR<br/>connections become weaker if stimuli not received</p> | (3)  |

Q2.

| Question Number | Answer                                                                                                                                                                                                                                                                                                    | Additional Guidance                                                                             | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|------|
|                 | <p>In sensory neurone:</p> <ol style="list-style-type: none"> <li>1. dendron longer;</li> <li>2. dendron myelinated ;</li> <li>3. axon shorter ;</li> <li>4. {cell body / eq} {not at the end / towards the middle / to the side / eq } ;</li> <li>5. reference to no {motor end plate / eq} ;</li> </ol> | <p>ALLOW converse for motor neurone</p> <p>4. <b>ACCEPT</b> centron / nucleus for cell body</p> | (3)  |

Q3.

| Question Number | Answer                                                                                                                                                                                                                                                 | Additional Guidance | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
|                 | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• antagonistic (interaction) of muscles (1)</li> <li>• in the iris (1)</li> <li>• radial muscles contract and circular muscles relax (1)</li> </ul> |                     | (3)<br>Exp |

Q4.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                            | Additional guidance | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (i)             | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• (DNA) ligase (joins the two genes) (1)</li> <li>• by joining phosphate to sugar / forming phosphodiester bonds (1)</li> <li>• by condensation reactions (1)</li> <li>• description of role of active site of enzyme (1)</li> </ul> |                     | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                 | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <p><b>The only correct answer is D restriction endonuclease</b></p> <p><i>A is not correct because DNA polymerase catalyses the formation of new DNA strands</i></p> <p><i>B is not correct because RNA ligase joins sections of RNA</i></p> <p><i>C is not correct because RNA polymerase catalyses the formation of pre-mRNA</i></p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                  | Additional guidance | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (iii)           | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• so that only bacteria with the antibiotic resistance gene survive (1)</li> <li>• therefore, these bacteria will also have the gene for spider silk (1)</li> </ul> |                     | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                          | Additional guidance                                                                                                                         | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|
| (iv)            | <p>An answer that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>• IAA to cause cell elongation (1)</li> <li>• detail of how IAA affects plant cells (1)</li> <li>• to grow plants that produce spider silk (1)</li> </ul> | <p>ALLOW alters pH of cell wall / makes cellulose cellwall more plastic / effect on transcription</p> <p>ALLOW stimulates roots to grow</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                       | Additional guidance                                                                                                                                                                                                                                   | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (v)             | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• mass per acre per year for goats (1)</li> <li>• correct calculation of difference in mass of spider silk produced (1)</li> <li>• correct percentage increase (1)</li> </ul> | <p>Example of calculation</p> <p><math>10 \times 12 = 120</math> (kg per acre per year)</p> <p><math>218 - 120 = 98</math> (kg per acre per year)</p> <p><math>81.66 / 81.7 / 82</math> (%)</p> <p>Correct answer with no working gains fullmarks</p> | (3)  |

Q5.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                                          | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|------|
| (i)             | <p>A description that makes reference to two of the following points:</p> <ul style="list-style-type: none"> <li>• MDMA { stimulates release / prevents re-uptake / increases concentration } of serotonin (1)</li> <li>• blocking pre-synaptic receptors / binding to post synaptic receptors (1)</li> <li>• nerve pathways using serotonin are more likely to be stimulated / more action potentials produced (1)</li> </ul> | <p>ALLOW reference to dopamine instead of serotonin</p> <p>ALLOW more impulses generated</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                            | Additional guidance                                       | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|------|
| (ii)            | <p>An explanation that makes reference to two of the following points:</p> <ul style="list-style-type: none"> <li>• MDMA use results in depletion of serotonin (1)</li> <li>• post synaptic membrane becomes less responsive to serotonin / loss of receptors on post synaptic membrane (1)</li> <li>• serotonin levels affect mood / lack of serotonin associated with depression (1)</li> </ul> | <p>ALLOW dopamine instead of serotonin for all points</p> | (2)  |

Q6.

| Question Number | Acceptable Answer                                                 | Additional Guidance | Mark |
|-----------------|-------------------------------------------------------------------|---------------------|------|
| (i)             | $58 - 45 = 13$<br>$(13 \div 58) \times 100$ (1)<br>$= 22.4\%$ (1) |                     | (2)  |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                        | Additional Guidance | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (ii)            | An answer that makes reference to the following: <ul style="list-style-type: none"> <li>mass higher in A ( compared with B) for both studies (1)</li> <li>the difference is less in repeat study / mass lower in repeats (of both A and B (1)</li> </ul> |                     | (2)  |

Q7.

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional Guidance | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
|                 | An answer that makes reference to four of the following points: <ul style="list-style-type: none"> <li>plants grown in pots containing same {soil / pH / minerals / water} as these factors can affect growth (1)</li> <li>one group under lamp emitting red light and one group under a lamp emitting far red light / one group under lamp emitting red and far red light at same intensity and one group under lamp emitting far red light at higher intensity than red (1)</li> <li>keep temperature the same in both as enzymes involved in growth (1)</li> <li>reference to {several groups of pots / multiple plants} to ensure results are {reliable / suitable for valid statistical analysis} (1)</li> <li>use {cloned / genetically identical} plants of same species as genes can affect growth (1)</li> </ul> |                     | (4)  |

Q8.

| Question Number | Answer                                                                                                                                                                                                                                                                                                              | Mark               |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| (i)             | <ul style="list-style-type: none"> <li>C -60 millivolts</li> </ul> <p><i>The answer is not A as - 80 millivolts is the maximum hyperpolarisation</i></p> <p><i>The answer is not B as - 70 millivolts in the resting potential</i></p> <p><i>The answer is not D as + 40 millivolts is the action potential</i></p> | (1)<br><b>Comp</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional Guidance                                                                                                                      | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------|
| (ii)            | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>voltage gated sodium ion channels open and sodium ions {diffuse into / move in } from outside the cell (1)</li> <li>(therefore causing an) increase in sodium ion concentration (1)</li> <li>voltage gated potassium ion channels open and potassium ions {diffuse out / move out} from the inside (1)</li> <li>(therefore causing an) decrease in potassium ion concentration at or after { 7 milliseconds / 40 mV } (1)</li> </ul> | <p>ALLOW sodium gates for voltage gated sodium ion channels</p> <p>ALLOW decrease in potassium ion concentration with repolarisation</p> | (4)<br>Exp |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                       | Additional Guidance                                                                                                                                                           | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| (iii)           | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>potassium ions (continue) leaving the {axon / cytoplasm} (1)</li> <li>(therefore) preventing another depolarisation occurring / it is the refractory period (1)</li> <li>allowing time for the neurone to reset (1)</li> <li>so that nerve impulses travel in one direction only (1)</li> </ul> | <p>ALLOW voltage gated potassium ion channels remain open</p> <p>ALLOW prevents an action potential from being generated</p> <p>ALLOW time to return to resting potential</p> | (3)<br>Exp |

Q9.

| Question number | Answer                                                                                                                                                                                                                                            | Additional guidance                                                                                                                                                                                                                                                                                                                                                                             | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>the benefits of the research outweigh any harm done (1)</li> <li>need to carry out experiments on animals with a well-developed CNS (1)</li> </ul> | <p>ALLOW CNS and spinal cord injuries are difficult to treat / CNS and spinal cord injuries have serious impact on people's lives / important research</p> <p>ALLOW experiments on tissues or invertebrates would not be sufficient</p> <p>IGNORE better than using humans / humans have more rights etc</p> <p>IGNORE have similar immune system / have less well developed nervous system</p> | (2)  |

Q10.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                             | Mark                     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
|                 | <p>An answer that makes reference to four of the following:</p> <p>Argument in favour</p> <ul style="list-style-type: none"> <li>a utilitarianism – the overall benefits of the experiments are greater than any harm done (1)</li> <li>welfare argument - animals can be used if they are treated well as far as possible (1)</li> </ul> <p>Argument against</p> <ul style="list-style-type: none"> <li>rights argument - all animals have rights (not just humans) (1)</li> <li>results may not be applicable to humans (1)</li> <li>consent argument - animals are unable to give consent (as is required for human trials) (1)</li> </ul> | <p>e.g. animals can be used if their use is regulated</p> <p>e.g. it is not acceptable to keep animals in laboratory cages / not acceptable to cause pain suffering to mice</p> | <p>Expert</p> <p>(4)</p> |

Q11.

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                 | Additional Guidance | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(i)</b>      | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• utilitarian argument, better to test on animals than on humans (1)</li> <li>• the benefits to humans must outweigh harm done to other animals (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                   | Additional Guidance | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(ii)</b>     | <p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>• to determine safe dose (1)</li> <li>• to determine side effects (1)</li> <li>• to determine how the drug is metabolised (1)</li> </ul> |                     | <b>(2)</b> |

Q12.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p><u>Indicative content:</u></p> <p><u>Benefits</u></p> <p>Described:</p> <ul style="list-style-type: none"> <li>• crops have increased yield due to pest control or resistance to disease</li> <li>• reduced need to use pesticides</li> <li>• crops can be grown in a wider range of conditions, e.g. harsh conditions, drought etc</li> </ul> <p>Discussed:</p> <ul style="list-style-type: none"> <li>• hybridisation could allow crop plants to have genes for tolerance to harsh conditions from genome D</li> <li>• crops have higher nutrient content, or produce a greater range of useful chemicals e.g. pharmaceutical products</li> <li>• genetic modification can be beneficial if crops are resistant to herbicides - crops can be sprayed with herbicide without { being harmed / causing reduction in yield }</li> </ul> <p><u>Risks</u></p> <p>Hybridisation:</p> <ul style="list-style-type: none"> <li>• hybridisation can lead to pest species which have ability to grow in wide range of conditions</li> <li>• hybridisation could allow genes for tolerance to harsh conditions from genome D to enter pest species</li> </ul> <p>GM:</p> <ul style="list-style-type: none"> <li>• genetic modification may result in genes entering pest species, making control difficult or into food chains</li> <li>• GM can introduce antibiotic resistant genes to other species</li> </ul> <p>Selective breeding</p> <ul style="list-style-type: none"> <li>• selective breeding reduces { genetic diversity / size of gene pool }, or causes genetic drift</li> <li>• leading to loss of useful alleles / reducing the ability of the crops to adapt to environmental change</li> </ul> |

| Level | Mark | Descriptor                                                                                                                                                                                                                                                                                                                                        | Additional Guidance                                                                                                                                                |
|-------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | 0    | No awardable content                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                    |
| 1     | 1-2  | <p>Limited scientific judgement made with a focus on <b>one</b> side of the argument only.</p> <p>A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.</p>                                                                     | Only considered one benefit <b>or</b> one risk without further explanation beyond a brief description.                                                             |
| 2     | 3-4  | <p>A scientific judgement is made through the application of relevant evidence to <b>both</b> sides of the argument.</p> <p>A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.</p>                                                 | Considers at least one risk <b>and</b> one benefit with some discussion.                                                                                           |
| 3     | 5-6  | <p>A scientific judgement is made, which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information.</p> <p>A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.</p> | <p>Benefits generally described and specific risks discussed.</p> <p>Conclusions described for each of the three methods – hybrids, GM and selective breeding.</p> |

Q13.

| Question Number | Acceptable Answer                               | Additional Guidance | Mark       |
|-----------------|-------------------------------------------------|---------------------|------------|
| <b>(a)</b>      | pyruvate and { reduced coenzyme / reduced NAD } |                     | <b>(1)</b> |

| Question Number | Acceptable Answer                                                                                                                     | Additional Guidance | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(b)(i)</b>   | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>Final electron acceptor</li> </ul> |                     | <b>(1)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                    | Additional Guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(b)(ii)</b>  | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>carbon monoxide binds to cytochrome oxidase (1)</li> <li>prevents oxygen binding to the enzyme (1)</li> <li>blocks the electron transport chain / prevents oxidation of reduced electron carriers (1)</li> </ul> |                     | <b>(3)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                           | Additional Guidance | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(c)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• NO binds to cytochrome oxidase in endothelium (of blood vessels) (1)</li> <li>• diverts oxygen to smooth muscle cells (1)</li> <li>• contraction of muscle cells causes vasoconstriction in arterioles (1)</li> </ul> |                     | <b>(3)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                          | Additional Guidance | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| <b>(d)</b>      | <p>An answer that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• free radicals interact with transcription factors (1)</li> <li>• activation of gene for P53 (1)</li> <li>• production of mRNA from activated gene (1)</li> </ul> |                     |      |

| Question Number | Acceptable Answer                                                                                                | Additional Guidance | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------|---------------------|------------|
|                 | <ul style="list-style-type: none"> <li>translation of mRNA resulting in synthesis of P53 on ribosomes</li> </ul> | (1)                 | <b>(3)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional Guidance | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(e)</b>      | <p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>inner membrane { is folded / has a larger surface area / has cristae } (1)</li> <li>outer membrane is impermeable to <math>H^+</math> ions (1)</li> <li>only inner membrane contains { ETC (proteins) / ATP synthase / stalked particles } (1)</li> <li>only inner membrane contains <math>H^+</math> pump (1)</li> </ul> |                     | <b>(3)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                    | Additional Guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(f)</b>      | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>myocardial infarction causes cell death in the heart (1)</li> <li>due to lack of oxygenated blood reaching cardiac muscle cells (1)</li> <li>NIR affects cytochrome oxidase involved in aerobic respiration (1)</li> <li>diversion of oxygen to cardiac muscle cells would reduce death of these cells (1)</li> </ul> |                     | <b>(4)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                             | Additional Guidance | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(g)(i)</b>   | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• restriction endonuclease enzyme (1)</li> <li>• extraction of gene that codes for light-sensitive protein (1)</li> <li>• use of a suitable vector (1)</li> <li>• insertion of gene into the { genome / DNA } in the nucleus of the neurone (1)</li> </ul> |                     | <b>(4)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional Guidance | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(g)(ii)</b>  | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• { depolarisation / action potential } occurs (1)</li> <li>• (nerve) impulse reaches { synapse / presynaptic membrane } (1)</li> <li>• calcium ion channels open causing calcium ions to enter presynaptic neurone (1)</li> <li>• vesicles containing neurotransmitter fuses with presynaptic membrane (1)</li> <li>• neurotransmitter released (1)</li> </ul> |                     | <b>(5)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional Guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(h)</b>      | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• fMRI detects changes in blood flow in the brain (1)</li> <li>• MRI signal reflects state of haemoglobin / magnetic fields repelled by oxygen rich blood / deoxygenated haemoglobin more magnetic than oxygenated haemoglobin (1)</li> <li>• allows areas of greater brain activity to be detected as an image created by magnetic resonance (1)</li> <li>• areas of the brain that are involved in an auditory memory task { were using more oxygen / had an increased flow of blood } (1)</li> </ul> |                     | <b>(3)</b> |

Q14.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional guidance                                                                                              | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>potential difference across axon changing (1)</li> <li>due to increased permeability to sodium ions / (voltage gated) sodium channels open (1)</li> <li>sodium ions { move into the axon / cause depolarisation } (1)</li> <li>(followed by) an increased permeability to potassium ions / potassium channels open (1)</li> <li>potassium ions { move out of the axon / cause repolarisation of the membrane } (1)</li> </ul> | <p>e.g. when depolarised from negative to positive or from -70mV to +40mV or repolarised from +40mV to -70mV</p> | (4)  |

Q15.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                  | Additional Guidance                                                                                                                                                                         | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>changing a base results in a change in the triplet code</li> <li>this changes the codon(s) in the mRNA</li> <li>resulting in a different { amino acid / amino acid sequence } (in the primary structure)</li> </ul> | <p>ALLOW deletion / substitution / insertion / frameshift. ALLOW illustration of change in triplet code e.g. ATT to ATG</p> <p>ALLOW introducing a stop codon / terminating translation</p> | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                 | Additional Guidance                                                                   | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|------|
| (ii)            | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>sequence the genome of people with MPS1</li> <li>sequence the genome of a number of people without the condition</li> <li>compare the base sequences to identify mutations found only in individuals with the condition</li> </ul> | <p>ALLOW comparison of base sequences of people with MPS1 and people without MPS1</p> | (3)  |

Q16.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                 | Additional Guidance                                                                                                                                                               | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>no difference in action potential between individual with and individual without GBS</li> <li>motor neurone conduction speed is reduced</li> <li>due to { loss of myelin / demyelination } of the (motor) neurone</li> <li>(and therefore) loss of saltatory conduction</li> </ul> | <p>IGNORE reference to sensory neurone</p> <p>ALLOW reference to loss of Schwann cells<br/>DO NOT ALLOW destroy</p> <p>ALLOW impulse cannot pass between the nodes of Ranvier</p> | (4)  |

Q17.

| Question Number | Answer                                                                                                                                                                                                          | Additional Guidance                                                                                                                                                                                      | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>drugs not delivered to { other / healthy} tissues (1)</li> <li>overall dosage needed is less (1)</li> </ul> | <p>ALLOW drug does not {affect / reach} other tissues, drug not delivered to the whole body<br/>ALLOW converse</p> <p>ALLOW {higher concentration / more of the drug} delivered to area where needed</p> | (2)  |

Q18.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                           | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>plants respond to light / plants show phototropic responses (1)</li> <li>(therefore) light must be excluded in order to study the effects of gravity (1)</li> <li>(putting plants in the dark) therefore prevents light having an effect (1)</li> </ul> | <p>ALLOW plant shoots grow towards light</p> <p>ALLOW 'geotropism' for 'effects of gravity'</p> <p>ALLOW to control light</p> | (3)  |

| Question Number | Answer                                                                                                                                                              | Additional guidance                                                                                                                                                                                                                                                       | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <ul style="list-style-type: none"> <li>correct values selected from the graphs (1)</li> <li>correct calculation of mean rate of curvature with units (1)</li> </ul> | <p><u>Example of calculation</u></p> <p>58 and 9</p> <p><math>49 \div 23 = 2.1</math> {degrees per day / ° day<sup>-1</sup>}</p> <p>ALLOW 2.13 degrees per day</p> <p>Correct answer without working gains full marks</p> <p>Correct value without units gains 1 mark</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                  | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------|
| (iii)           | <p>An answer the makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>do not have allele conferring ability to respond to gravity / only have alleles that confer a lack of response to gravity (1)</li> <li>(so) do not produce {IAA / auxin} (1)</li> <li>(therefore) lack of stimulation of cell elongation on side of stem facing downwards (1)</li> </ul> | <p>ALLOW cells present in the stem fail to detect gravity</p> <p>ALLOW there is no auxin present</p> | (2)  |

Q19.

| Question number | Answer                                                                                                                                                                                                                                                                                                       | Additional guidance                                                                                        | Mark                     |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|--------------------------|
|                 | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>sequencing the {genome / genes / DNA} of people with (and without) ASD (1)</li> <li>identify (genes that have) {mutations / differences in sequence} (between ASD and non-ASD individuals) (1)</li> </ul> | <p>ALLOW compare genomics of people with and without ASD</p> <p>ALLOW DNA profiling of people with ASD</p> | <p>Expert</p> <p>(2)</p> |

Q20.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                     | Mark        |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
|                 | <ul style="list-style-type: none"> <li>Diagram C</li> </ul> <p><i>The answer is not diagram A because the labelled regions do not match the descriptions</i></p> <p><i>The answer is not diagram B because the labelled regions do not match the descriptions</i></p> <p><i>The answer is not diagram D because the labelled regions do not match the descriptions</i></p> | (1)<br>comp |

Q21.

| Question Number | Answer                                                                                                                                                                                                                                                                                         | Additional Guidance                                                                                                                                                                    | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| (i)             | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>due to more activity (1)</li> <li>an increase in { oxygenated blood / blood flow } to this region (1)</li> <li>fMRI signals { reflected / not absorbed } by oxygenated blood (1)</li> </ul> | <p>ALLOW increased aerobic respiration</p> <p>ALLOW oxyhaemoglobin or oxygen-rich blood for oxygenated blood</p> <p>ALLOW oxyhaemoglobin or oxygen-rich blood for oxygenated blood</p> | (3)<br>Exp |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                              | Additional Guidance                                                                                                                        | Mark                             |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| (ii)            | <p>A description that makes reference to three of the following</p> <ul style="list-style-type: none"> <li>• (using both provides information on) function (PET) and structure (1)</li> <li>• PET scan shows areas that are {more (metabolically) active / dividing more } (1)</li> <li>• CT scan gives {location / size} (1)</li> <li>• each scan uses a different technique / techniques described (1)</li> </ul> | <p>ALLOW reference to 3D images (with PET and CT)</p> <p>e.g. CT uses X-rays and PET radioactively labelled metabolite such as glucose</p> | <p><b>(3)</b><br/><b>Exp</b></p> |

Q22.

| Question Number | Acceptable Answer                                                                                                                                                                                                                                         | Additional Guidance | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(a)(i)</b>   | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>gene is a length of DNA that codes for a { polypeptide / protein } (1)</li> <li>genome is a complete set of { DNA / introns and exons } (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer  | Additional Guidance | Mark       |
|-----------------|--------------------|---------------------|------------|
| <b>(a)(ii)</b>  | ligase / integrase |                     | <b>(1)</b> |

| Question Number | Acceptable Answer | Additional Guidance | Mark       |
|-----------------|-------------------|---------------------|------------|
| <b>(a)(iii)</b> | plasmid / virus   |                     | <b>(1)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                    | Additional Guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(a)(iv)</b>  | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>transcription of DNA to mRNA (1)</li> <li>{ translation of mRNA / protein synthesis } on ribosomes (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                               | Additional Guidance | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(b)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• no prothrombin activated so thrombin not produced (1)</li> <li>• thrombin needed to convert fibrinogen to fibrin (1)</li> <li>• fibrin needed to trap { platelets / blood cells } to form the (blood) clot (1)</li> </ul> |                     | <b>(3)</b> |

Q23.

| Question Number | Acceptable Answer                                                                                                                                                                                 | Additional Guidance | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(a)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• fraternal twins risk is lower (1)</li> <li>• because fewer alleles in common (1)</li> </ul> | Allow converse      | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                       | Additional guidance | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(b)(i)</b>   | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• Identical twins being raised apart allows environmental factors to be investigated separately from genetic factors (1)</li> <li>• therefore may be able to determine relative amount of risk due to genetic variation / relative amount of risk due to environment (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                     | Additional guidance             | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------------|
| <b>(b)(ii)</b>  | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• twins have more in common than shared genetics / shared uterine environment (1)</li> <li>• twins may be raised in similar environments(1)</li> </ul> | Ignore reference to sample size | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Additional guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(c)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• Parkinson's symptoms arise due to low dopamine levels (1)</li> <li>• transmission of nerve impulses disrupted causing lack of control of {muscle movements / tremors} (1)</li> <li>• schizophrenia drugs lower {neurotransmitter / dopamine} levels (1)</li> </ul> <p>Plus two from:</p> <ul style="list-style-type: none"> <li>• therefore less dopamine in synaptic / knob secreted into cleft / diffuses across cleft (1)</li> <li>• therefore less dopamine available to bind to receptors (1)</li> <li>• therefore no/little change in membrane structure / permeability of post- synaptic cell (1)</li> <li>• therefore fewer sodium ions enter postsynaptic cell (1)</li> <li>• therefore less depolarisation of postsynaptic cell (1)</li> </ul> |                     | <b>(5)</b> |

Q24.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>(a)</b>      | <ol style="list-style-type: none"> <li>1. reference to {restriction enzyme / endonuclease} ;</li> <li>2. to cut gene out of animal DNA ;</li> <li>3. idea of amplification using DNA polymerase (in PCR) ;</li> <li>4. (enzymes) open plasmid ;</li> <li>5. (same endonuclease) to produce 'sticky ends' /description / at selected base sequence ;</li> <li>6. H bonds formed between bases at 'sticky ends' ;</li> <li>7. ligase ;</li> <li>8. to join gene to plasmid / eq ;</li> <li>9. reference to {phosphodiester / eq} bond ;</li> </ol> | <b>(5)</b> |

| Question Number | Answer                                                                                                                                                                                                           | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>(b)</b>      | <ol style="list-style-type: none"> <li>1. (small) {circle /eq} of DNA ;</li> <li>2. containing bacterial (survival) genes and {protein / animal} gene ;</li> <li>3. marker gene / description given ;</li> </ol> | <b>(2)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>(c)</b>      | <ol style="list-style-type: none"> <li>1. idea of easier to manage growth e.g. do not need sterile conditions ;</li> <li>2. idea that it is safer (than bacteria) ;</li> <li>3. idea of more protein can be made /eq ;</li> <li>4. bacteria may not have correct amino acids to make protein / eq ;</li> <li>5. idea that it could produce edible drugs ;</li> <li>6. idea that plants have introns/bacteria do not so gene does not need modifying ;</li> <li>7. idea that it is cheaper ;</li> </ol> | <b>(2)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>(d)</b>      | <ol style="list-style-type: none"> <li>1. idea of gene transfer to other {species / eq} ;</li> <li>2. idea of consequence of transfer e.g. resistance to pesticide / antibiotics, superweeds ;</li> <li>3. idea of possible harmful effects from genes e.g. biochemical changes to substances that could act as allergens, long term effects of consuming ;</li> <li>4. idea that benefit focused on developed countries / converse ;</li> <li>5. idea of risk related to use of viral vectors ;</li> <li>6. idea of effect on organic farmers ;</li> </ol> | <b>(2)</b> |

| Question Number | Answer                                                                                                                                                        | Additional Guidance                                                         | Mark              |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------|
|                 | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>all the {DNA / exons and introns}</li> </ul> <p><b>(1)</b></p> | <p>DO NOT ALLOW 'all the genes in the DNA' / 'all the DNA in the genes'</p> | <p><b>(1)</b></p> |

Q1.

**Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

Genome sequencing and genetic modification (GM) can be used to develop proteins as personalised medicines.

(i) Which of the following correctly describes the genome of an adult male?

(1)

- ☐ **A** all of his alleles plus all of his genes
- ☐ **B** all of his exons minus all of his introns
- ☐ **C** all of his introns minus all of his exons
- ☐ **D** all of his introns plus all of his exons

(ii) Which row correctly identifies all the types of organism that can be both genetically modified and be a

source of a gene to be used in GM?

(1)

|                                   | Animal | Bacterium | Plant |
|-----------------------------------|--------|-----------|-------|
| <input type="checkbox"/> <b>A</b> | no     | no        | yes   |
| <input type="checkbox"/> <b>B</b> | no     | yes       | yes   |
| <input type="checkbox"/> <b>C</b> | yes    | yes       | no    |
| <input type="checkbox"/> <b>D</b> | yes    | yes       | yes   |

**(Total for question = 2 marks)**

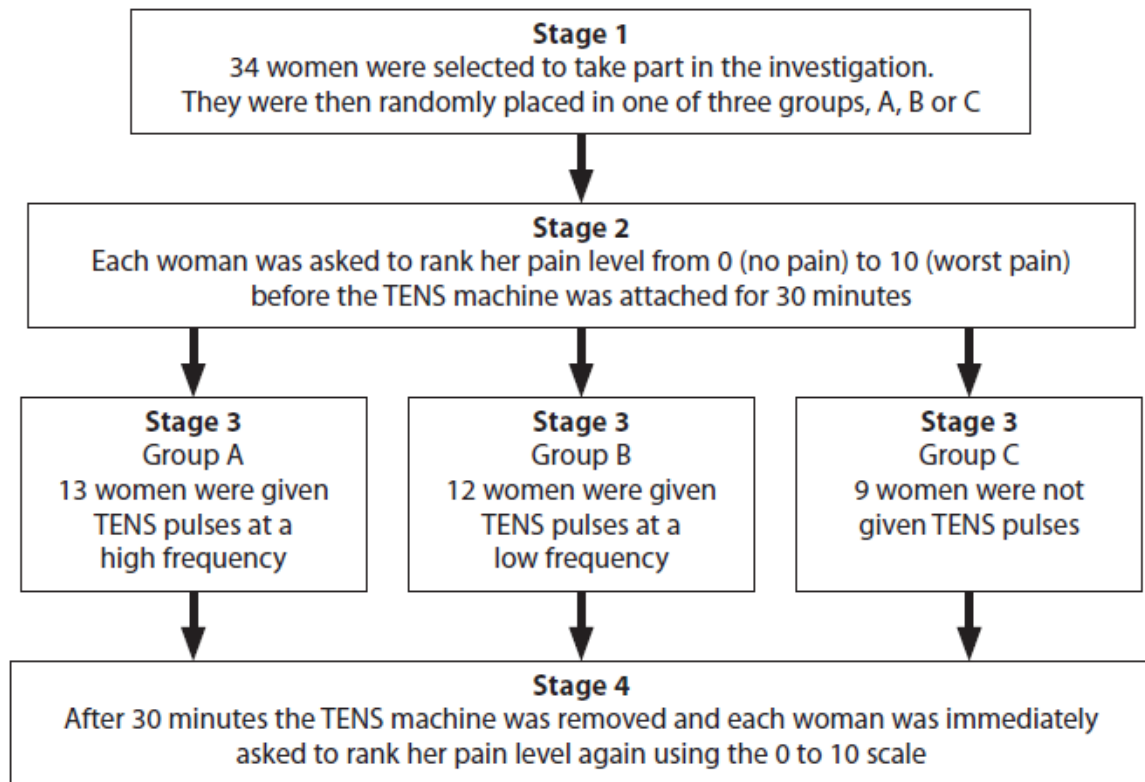
Q2.

Some women need to have surgery to aid childbirth. This can lead to pain after surgery.

A TENS (transcutaneous electrical nerve stimulation) machine releases regular pulses of electricity onto the skin surface and can be used in pain relief.

An investigation was carried out to study whether the frequency of the pulses from a TENS machine could help these women with their pain relief.

The diagram shows how the investigation was carried out.



This investigation used only one 30-minute session of TENS pulses. This was done to reduce the risk of habituation.

Describe the process that occurs at a synapse that leads to habituation.

(4)

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(Total for question = 4 marks)

Q3.

Habituation is a learning response observed in many types of animal.

Explain the importance of the habituation response in an animal.

(2)

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**(Total for question = 2 marks)**

Q4.

Plants can respond to environmental cues using IAA (auxin) and photoreceptors.

(a) A plant was kept in a cycle of 12 hours in the light and then 12 hours in the dark. This plant did not flower.

It was then placed in an environment with 15 hours in the light and 9 hours in the dark. The plant then flowered.

Explain how this change in light conditions stimulated this plant to flower.

(3)

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(b) IAA in the stem of the plant is involved in phototropism.

(i) Give **three** similarities between IAA and animal hormones.

(3)

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(ii) Auxins can be used to kill unwanted plants such as weeds growing in grass.  
The auxin stimulate the weeds to grow rapidly.

Suggest an explanation for how auxins stimulate the weeds to grow rapidly but not the grass.

(2)

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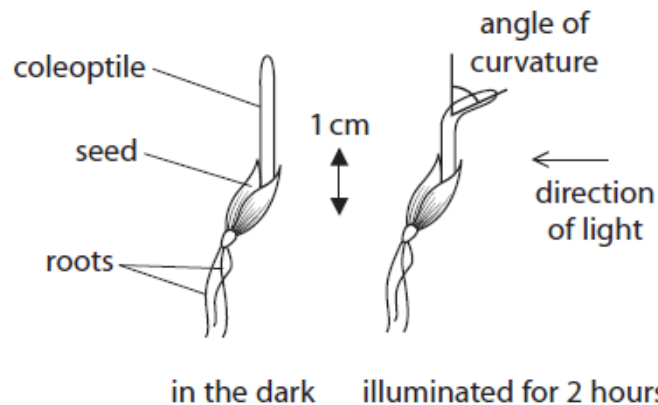
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**(Total for question = 8 marks)**

When oat seeds germinate, they produce roots and a coleoptile.

The effect of shading the tip of the coleoptile was investigated.

The diagram shows how the coleoptile of an oat seedling can bend towards light.



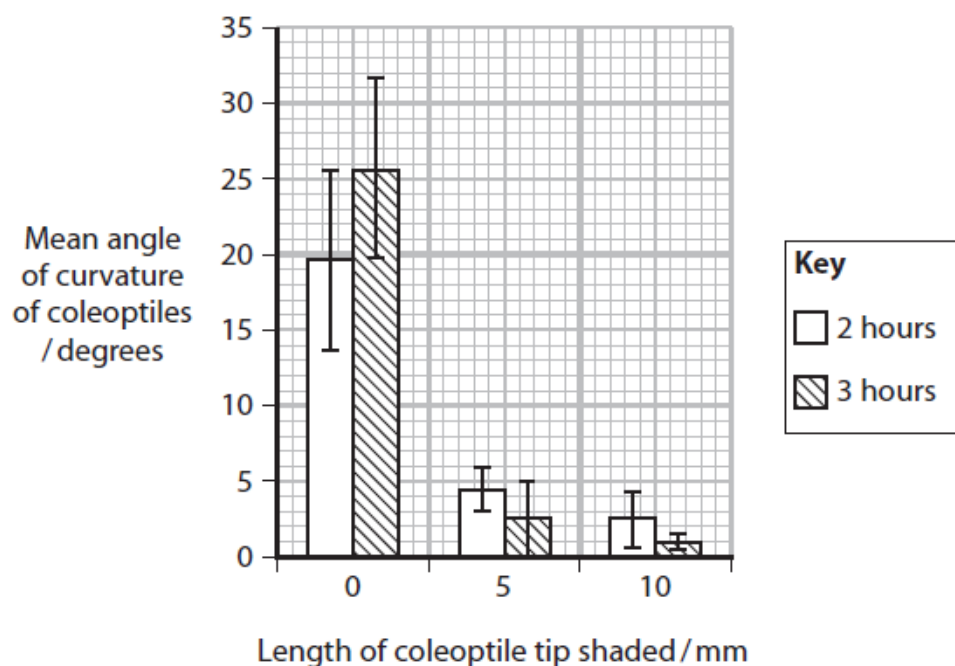
Oat seeds were germinated. When the coleoptiles were 2 cm long the seedlings were split into three groups.

- Group 1 none of the tip of the coleoptile was shaded
- Group 2 5 mm at the tip of the coleoptile was shaded
- Group 3 10 mm at the tip of the coleoptile was shaded

All the coleoptiles were then exposed to light from one side.

The curvature of the coleoptiles was measured after intervals of 2 hours and 3 hours.

The results of this investigation are shown in the graph.

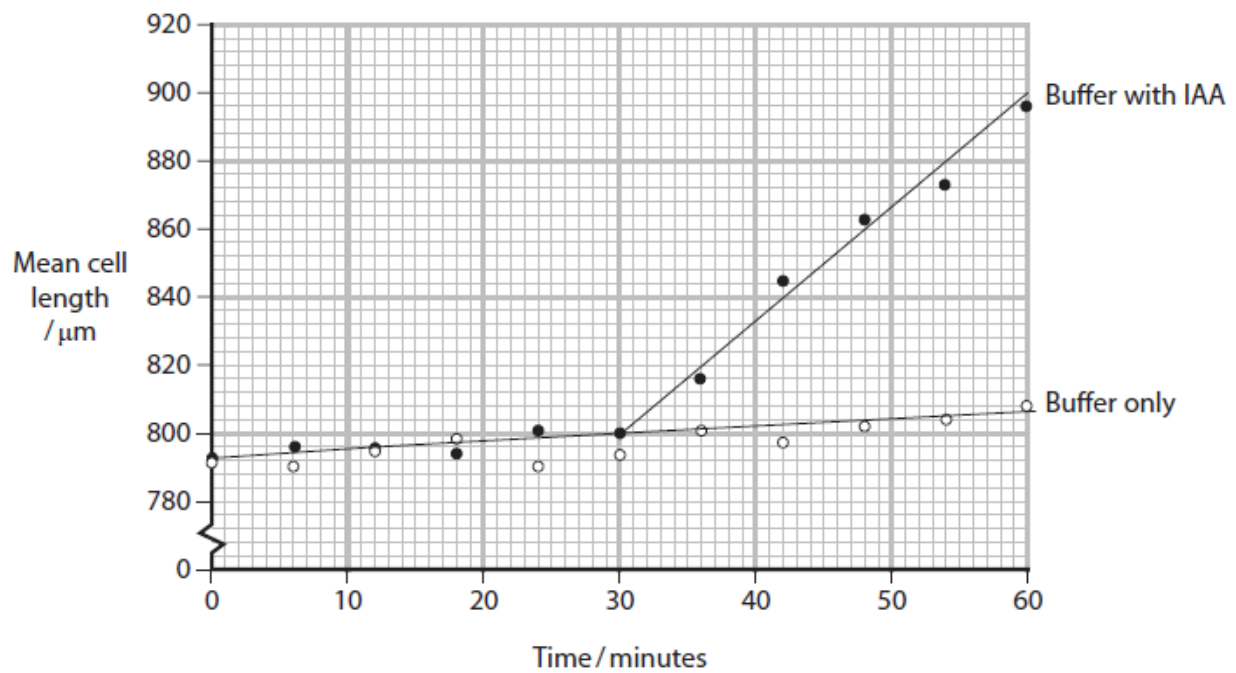


In a second investigation, cells were taken from below the tip of the coleoptile.

These cells were soaked in buffer alone or buffer containing IAA (auxin), for a period of 60 minutes.

The lengths of the cells were measured every six minutes.

The results of this investigation are shown in the graph.



Explain how the evidence from these investigations indicates that plant hormones are involved in the phototropic response of oat coleoptiles.

(3)

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**(Total for question = 3 marks)**

The scientific article you have studied is from *Scientific American*.

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

'A cytokine produced by immune cells in the meninges can change the activity of neurons, thereby altering the function of the circuit' (paragraph 20).

Cytokine has been found to affect neurotransmitter systems in the brain.

Explain how a cytokine could modify the activity of a neural circuit.

(4)

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**(Total for question = 4 marks)**

Q7.

The scientific article you have studied is adapted from *Scientific American*.

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

Describe how tumour shrinkage could be observed (paragraph 6).

(2)

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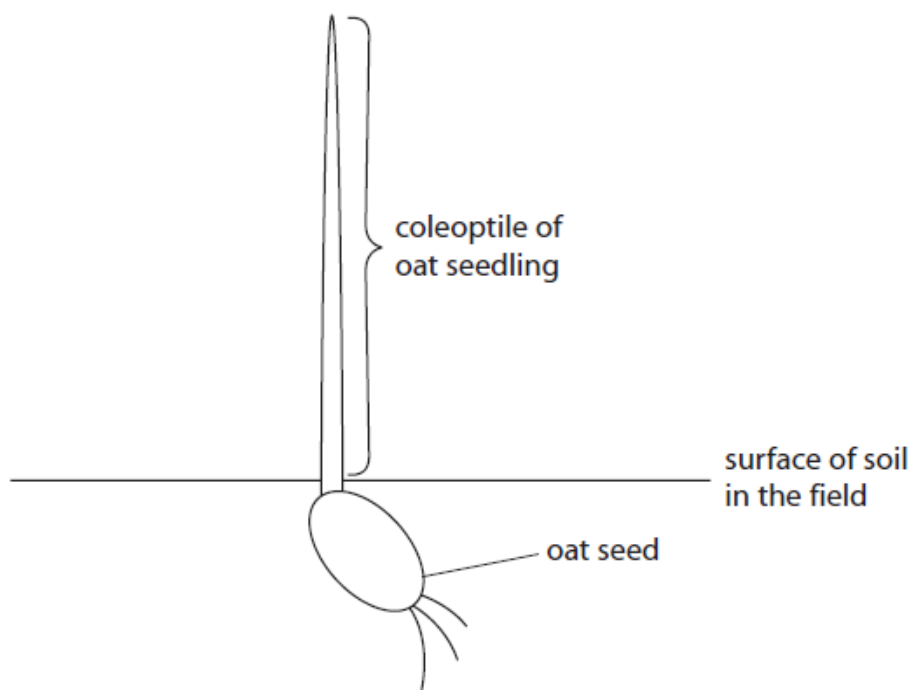
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**(Total for question = 2 marks)**

Q8.

Phytochromes and IAA (indole acetic acid) are important substances that bring about growth responses in plants.

The diagram shows an oat seedling in part of a field.



Cells in the tip of the oat coleoptile release IAA.

Explain how the IAA affects the growth of the coleoptile.

(4)

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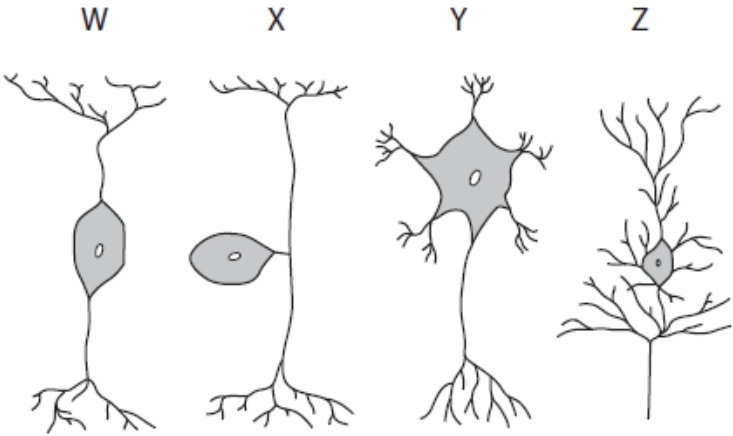
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**(Total for question = 4 marks)**

Q9.

People with Guillain-Barré syndrome (GBS) suffer from a rapid onset of muscle weakness. It is thought that GBS is caused by damage to the peripheral nervous system.

The diagram shows some typical neurones.



(i) Which of these is a sensory neurone?

**(1)**

☒ **A** W

☐ **B** X

☐ **C** Y

☐ **D** Z

(ii) The axons of some neurones are surrounded by a myelin sheath.

The main component of myelin is a glycolipid.

Glycolipids are formed from lipids attached to a chain of

(1)

☐ **A** amino acids which are joined by glycosidic links

☐ **B** amino acids which are joined by peptide bonds

☐ **C** sugar molecules which are joined by ester bonds

☐ **D** sugar molecules which are joined by glycosidic links

(iii) Describe the role of the dendrites in a neurone.

(3)

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**(Total for question = 5 marks)**

Q10.

An investigation was carried out to study the effect of positive and negative physical and emotional experiences on humans.

The positive physical experience was a warm object placed on the arm of a person for five seconds.

The negative physical experience was a hot object placed on the arm of a person for five seconds.

All other variables were kept constant.

Two groups of people were used in this investigation. In the first group, the warm object was used before the hot object. In the second group, the hot object was used before the warm object.

After each experience, the individuals were asked to rate their feelings using the scoring system below.

| Feelings  | Score |
|-----------|-------|
| Very bad  | 1     |
| Bad       | 2     |
| Neutral   | 3     |
| Good      | 4     |
| Very good | 5     |

This investigation then used a scanning technique to study whether the same areas of the brain were involved in both physical experiences and emotional experiences.

(i) Suggest the scanning technique required to study the brain in this investigation. Give reasons for your choice.

(3)

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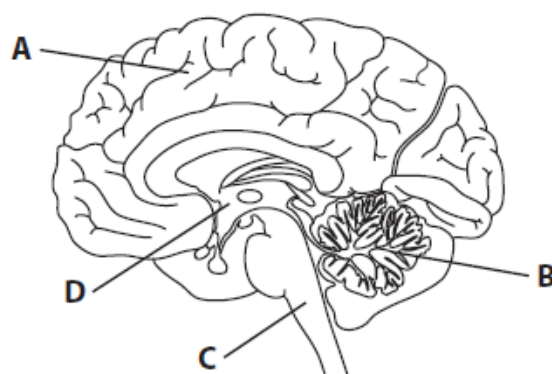
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(ii) It was found that an area of the brain called the insula was involved in both physical experiences and emotional experiences. The insula is found just above the hypothalamus.

Using the diagram below, place a cross in the box ☒ that identifies the area of the insula.

(1)



- ☒ A
- ☐ B
- ☐ C
- ☐ D

Q11.

**Answer the question with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

There are various ways to scan the brain.

(i) Brain tumours are dense masses of cells. The presence of brain tumours can be detected using several types of scanning method.

The table shows two types of scan. Place a tick [✓] in the box if the scan can identify the size and location of a large brain tumour or a cross [✗] in the box if the scan cannot identify the size and location of a large brain tumour.

| Type of scan | Can be used to identify the tumour |
|--------------|------------------------------------|
| CT           |                                    |
| MRI          |                                    |

(ii) Functional MRI (fMRI) measures brain activity by detecting changes in

(1)

- ☐ **A** blood flow
- ☐ **B** bone density
- ☐ **C** dopamine release
- ☐ **D** lactic acid production

(iii) Which of the following types of scanner uses X-rays?

(1)

- ☐ **A** CT
- ☐ **B** fMRI
- ☐ **C** MRI
- ☐ **D** PET

**(Total for question = 4 marks)**

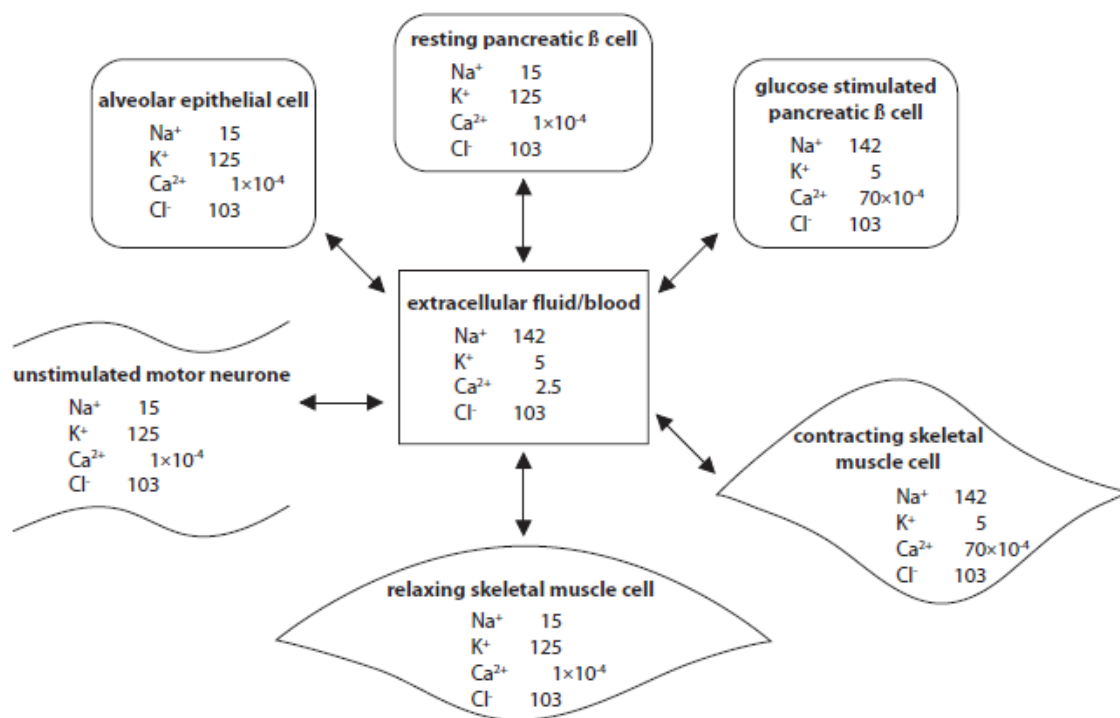
Q12.

\*Cells use ions in many different processes.

Ion transport across cell membranes is a fundamental property of all living cells.

The diagram shows some typical ion concentrations in healthy human cells and in the extracellular fluid.

All values are in  $\text{mmol dm}^{-3}$ .



The tables show information about the human genome and types of transport channel in humans.

| Some information about the human genome                                                                       |                                                                    |
|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Number of genes in the human genome                                                                           | approximately 20 000                                               |
| Number of genes coding for membrane proteins                                                                  | approximately 5 400                                                |
| Number of genes coding for proteins involved in the transport of ions across cell membranes                   | more than 350                                                      |
| Number of diseases associated with mutations in genes involved in the transport of ions across cell membranes | more than 28                                                       |
| Organs and systems in which ion channel mutations cause disease                                               | central nervous system, heart, lungs, pancreas and skeletal muscle |

| Type of transport channel  | Number of each type of transport channel |
|----------------------------|------------------------------------------|
| Voltage gated ion channels | 147                                      |
| Chloride channels          | 17                                       |
| Active transport           | 81                                       |

Discuss the importance of ion transport across membranes in human health and disease.

**(Total for question = 9 marks)**

Q13.

The muscles of the earthworm (*Lumbricus terrestris*) contract when it is touched. This is known as the withdrawal response.

Studies were carried out to investigate the withdrawal response in earthworms.

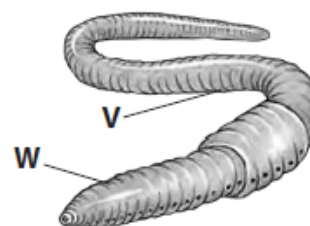
The duration of the withdrawal response is the length of time that the muscles remain contracted. If the stimulus is repeated, the withdrawal response is either reduced in duration or lost.

In one study, an earthworm was touched 20 times in one minute at point **V** as shown in the diagram. The shortening of the earthworm's body was measured after 20 stimuli.

The effect of touching point **W** in the same way was recorded and also the effect of alternating touches between points **V** and **W**.

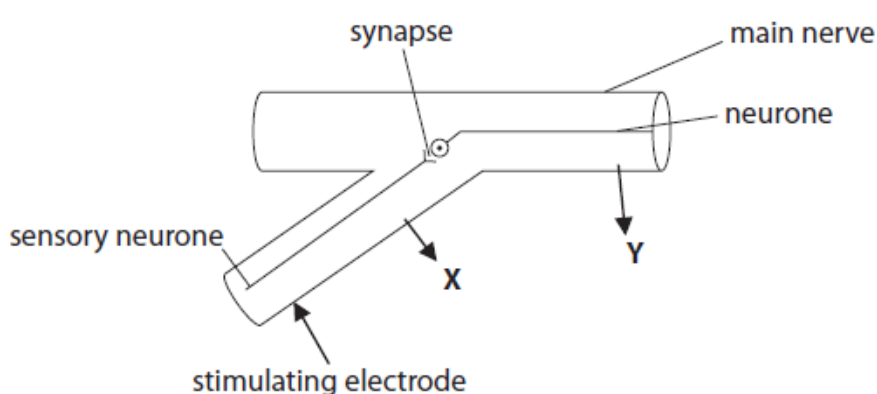
The results of this study are shown in the table.

| Nature of stimulus                                       | Change in body length after 20 stimuli / mm |
|----------------------------------------------------------|---------------------------------------------|
| All stimuli at point <b>V</b>                            | 0                                           |
| Stimuli alternating between points <b>V</b> and <b>W</b> | 17                                          |
| All stimuli at point <b>W</b>                            | 0                                           |

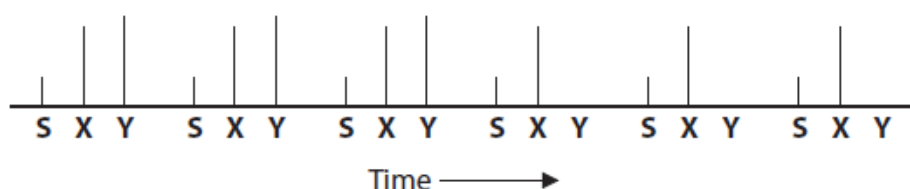


In another study, sensory neurones of an earthworm were stimulated by an electrode six times.

Nerve impulses were recorded at positions **X** and **Y** as shown in the diagram.



Nerve impulses recorded at **X** and **Y** are shown in the diagram below. The presence of a line indicates that an impulse was detected. **S** shows the stimulus.



\* (i) Analyse the data from these two studies to evaluate the most likely cause of the loss of the

withdrawal response.

(6)

[illegible]

(ii) Devise an experiment to show that the frequency of the stimulation used in the first study should be 20 stimuli per minute.

(4)

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**(Total for question = 10 marks)**

Q14.

The scientific article you have studied is from *Scientific American*.

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

It has been suggested that there is a critical period for the development of the hard wiring of the immune response into the brain (paragraphs 22 and 23).

Explain how this critical period could be investigated using animal experiments.

**(2)**

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**(Total for question = 2 marks)**

Q15.

When scientists visit Antarctica, they need appropriate clothing to help with thermoregulation.

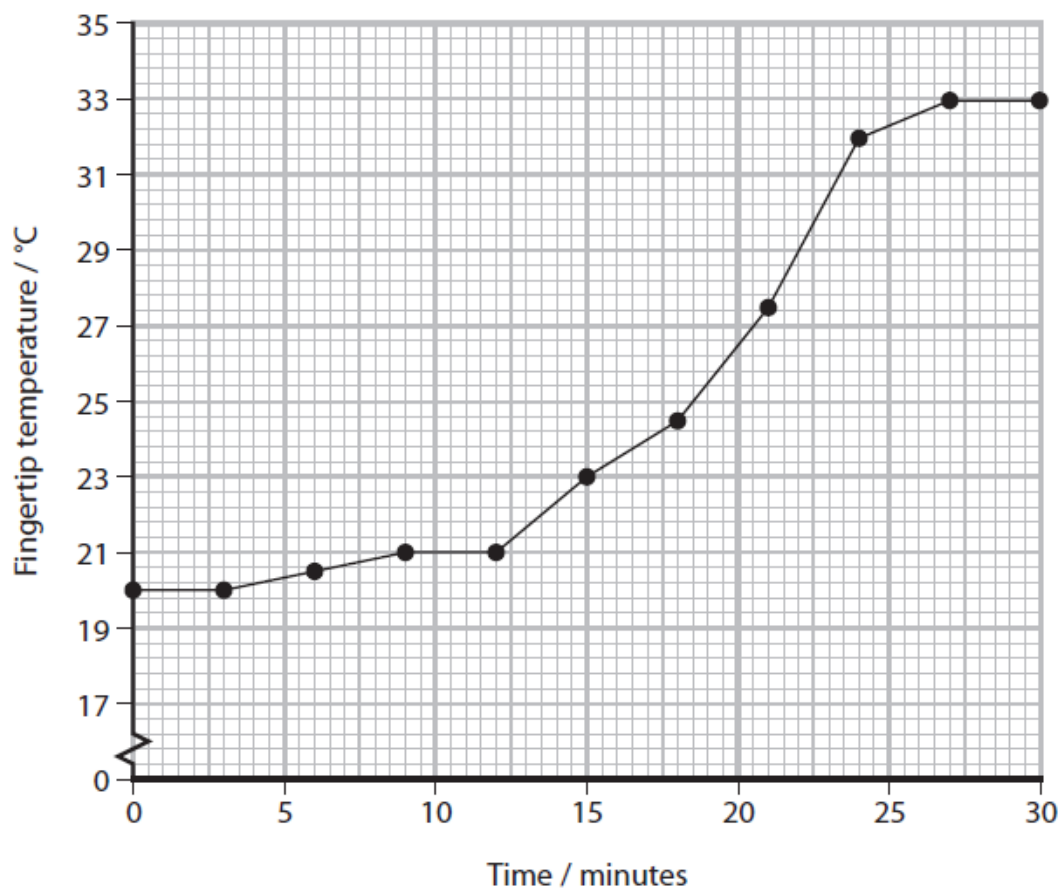


www.aa.com

An investigation was carried out to study thermoregulation in humans.

A woman was wrapped in blankets and her feet were put in hot water for 30 minutes. During this time, the temperature of the skin at the end of one of her fingertips was recorded.

The graph shows the results of this investigation.



(i) Explain why there was no change in fingertip temperature between 0 and 3 minutes.

(2)

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(ii) Calculate the greatest rate of increase in fingertip temperature.

(2)

Answer .....

(iii) Explain the role of the nervous system in bringing about the increase in temperature of the fingertip as shown in this investigation.

(5)

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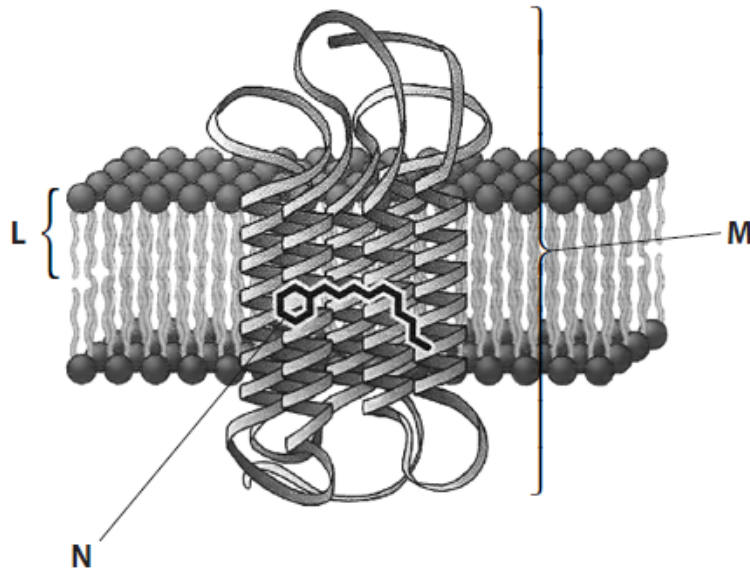
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**(Total for question = 9 marks)**

Q16.

The diagram shows part of the membrane of the outer segment of a rod cell.



(a) Which of the following is the part labelled **L**?

(1)

- ☐ **A** fatty acid tail
- ☐ **B** phosphate head
- ☐ **C** phospholipid
- ☐ **D** phospholipid bilayer

(b) (i) Give the name of the visual pigment labelled **M**.

(1)

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(ii) Give the name of the light-absorbing part of the visual pigment labelled **N**.

(1)

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(c) Describe how the absorption of light by the part labelled **N** results in an action potential in the optic nerve.

(3)

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**(Total for question = 6 marks)**

Q17.

Serotonin is found in the brain and is important in health and wellbeing.

An imbalance of serotonin can lead to problems such as depression. An individual with symptoms of depression may have low serotonin levels in the brain.

Describe how low serotonin levels in an individual can affect the transmission of impulses in their brain.

**(2)**

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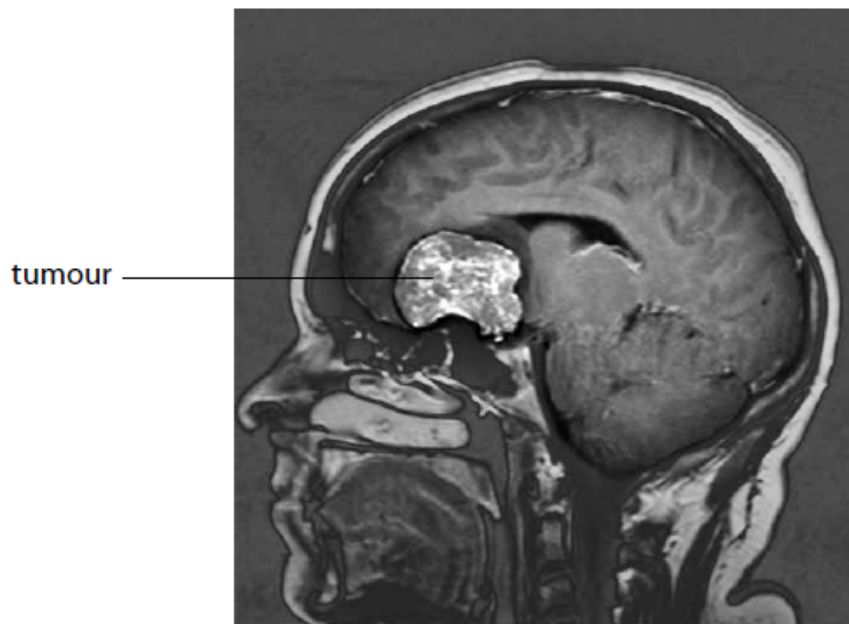
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**(Total for question = 2 marks)**

Q18.

Magnetic resonance imaging (MRI) can be used to study brain structure.

The MRI scan shows a human brain with a tumour.



© M210/0282 - Simon Fraser/Newcastle Hospitals NHS Trust/Science Photo Library

Magnification  $\times 0.3$

(a) The part of the brain in which the tumour has grown is the

(1)

- ☐ **A** cerebellum
- ☐ **B** cerebral hemisphere
- ☐ **C** hypothalamus
- ☐ **D** medulla oblongata

(b) Explain the advantages of using MRI scanning to identify tumours compared to using CT scanning.

(3)

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(c) fMRI scanning is another way of collecting information about the brain.

Explain how fMRI scanning would help neuroscientists to identify the part of the brain involved in controlling a voluntary action such as picking up a pen to write on paper.

(3)

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**(Total for question = 7 marks)**

Q19.

The neurones of the central nervous system contain TAU proteins. These proteins help to maintain cell structure.

In humans, six different TAU proteins can be produced from a single gene.

Parkinson's disease has been linked to the different forms of the TAU proteins present in neurones.

Scientists are studying the effect of these different TAU proteins in animal models.

One model used is the fruit fly, *Drosophila*.

Describe how *Drosophila* flies could be genetically modified to produce one form of the human TAU protein.

(4)

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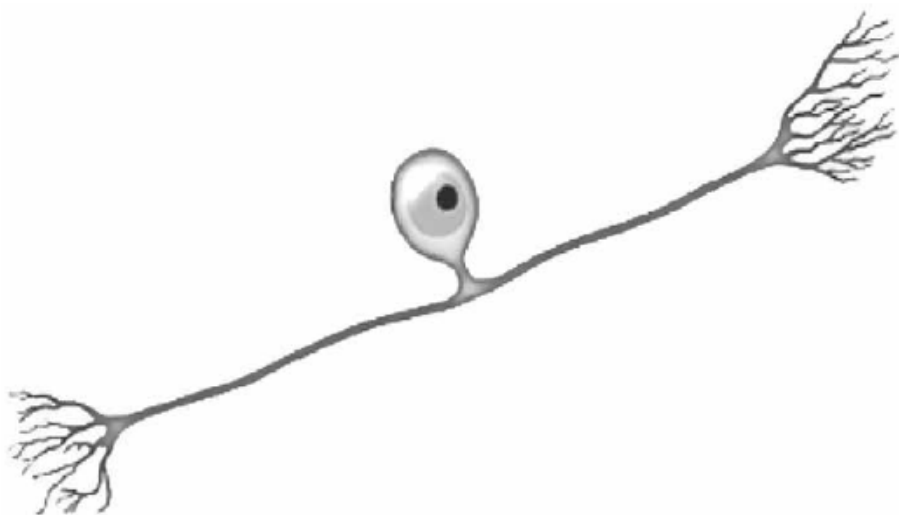
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(Total for question = 4 marks)

Q20.

The nervous system contains myelinated and unmyelinated neurones.

The diagram below shows a myelinated sensory neurone.



(a) Give **one** feature, shown in the diagram, that identifies this cell as a sensory neurone.

(1)

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(b) The table shows the conduction velocity of a nerve impulse along a myelinated and an unmyelinated neurone, each with a diameter of 5  $\mu\text{m}$ .

| Conduction velocity / $\text{ms}^{-1}$ |                      |
|----------------------------------------|----------------------|
| Myelinated neurone                     | Unmyelinated neurone |
| 24.9                                   | 5.1                  |

Explain why there is a difference in the conduction velocity of these neurones.

(5)

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**(Total for question = 6 marks)**

Q21.

Scientists have investigated the influence of both nature and nurture on brain development. They used several pairs of identical twins and several pairs of non-identical twins.

(a) In one investigation, each twin was shown a number of human faces and then asked to identify them amongst a group of unfamiliar faces.

The agreement in face identification between each pair of twins was recorded.

The results were used to calculate the mean percentage agreement in face identification for the two types of twin. This is shown in the table below.

| Mean percentage agreement in face identification (%) |                     |
|------------------------------------------------------|---------------------|
| identical twins                                      | non-identical twins |
| 70                                                   | 29                  |

(i) From these results, the scientists concluded that face identification has a genetic component. Explain how these results support this conclusion.

(4)

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(ii) This investigation was repeated using written words rather than faces. The mean percentage agreement in word identification for the two types of twin suggested that this involved an environmental component.

Suggest how the results of this investigation might differ from the results shown in the table.

(1)

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(b) Functional magnetic resonance imaging (fMRI) was used in another investigation. Brain activity was recorded whilst carrying out face identification.

Suggest why fMRI was used in this investigation.

(4)

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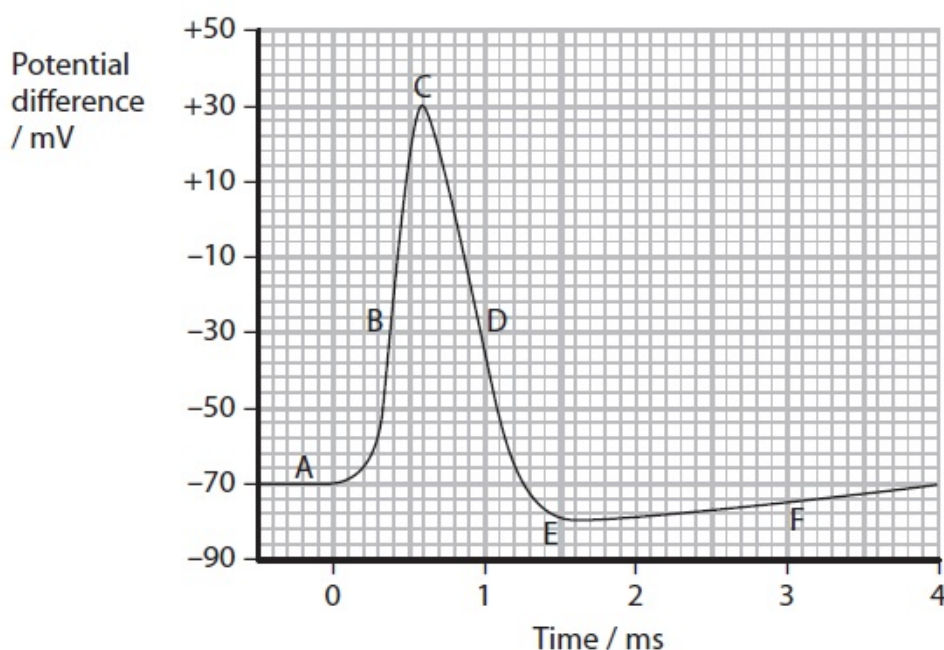
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**(Total for question = 9 marks)**

Q22.

(a) The graph below shows the changes in potential difference across the membrane of a neurone after stimulation.



(i) Using the information in the graph, state the maximum change in potential difference across the membrane of this neurone during depolarisation.

(1)

..... mV

(ii) The table below describes three of the stages shown in the graph.

Place a cross in the box (☒) below the letter that correctly links the description to one of the labels on the graph above.

(3)

| Description                                                               | A                        | B                        | C                        | D                        | E                        | F                        |
|---------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Stage when the concentration of positive ions is greatest inside the axon | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Stage when hyperpolarisation first occurs                                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Stage showing the resting potential                                       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

\*(b) When a nerve impulse reaches a synapse, calcium ions enter the neurone through the pre-synaptic membrane. This causes a neurotransmitter, such as acetylcholine, to be released.

Describe and explain the sequence of events that occurs at the synapse, after a neurotransmitter has been released.

(5)

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(Total for question = 9 marks)

Q23.

The neurones of the central nervous system contain TAU proteins. These proteins help to maintain cell structure.

In humans, six different TAU proteins can be produced from a single gene.

Parkinson's disease has been linked to the different forms of the TAU proteins present in neurones.

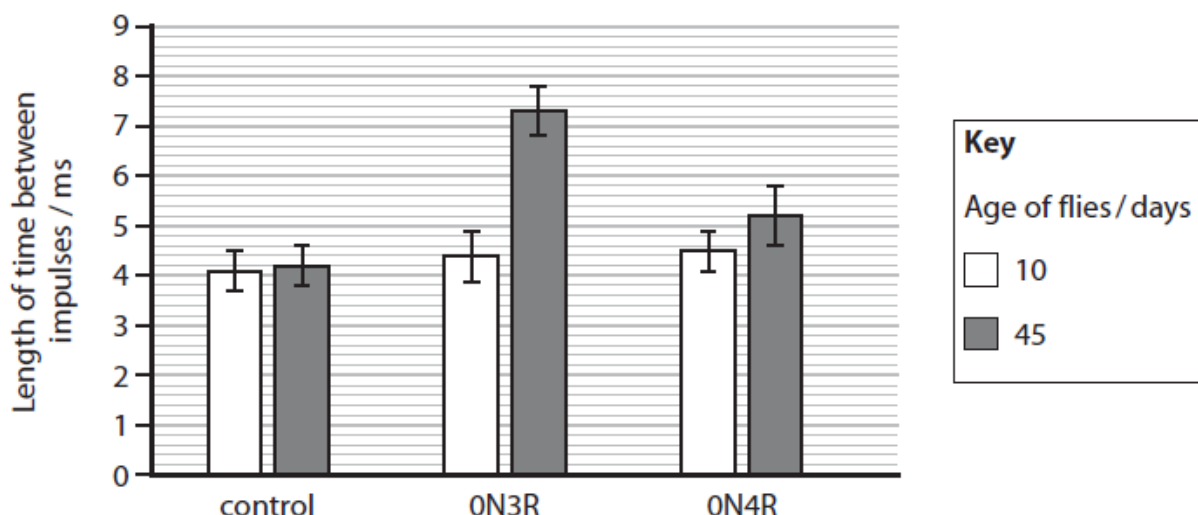
Scientists are studying the effect of these different TAU proteins in animal models.

One model used is the fruit fly, *Drosophila*.

In another investigation, the effect of these TAU proteins and age on the conduction of nerve impulses along the axon of neurones was studied.

The length of time between impulses was measured for *Drosophila* flies of different ages.

The results are shown in the graph.



Determine the effect of these TAU proteins on the maximum frequency at which nerve impulses can be conducted along the axon of the neurone.

(4)

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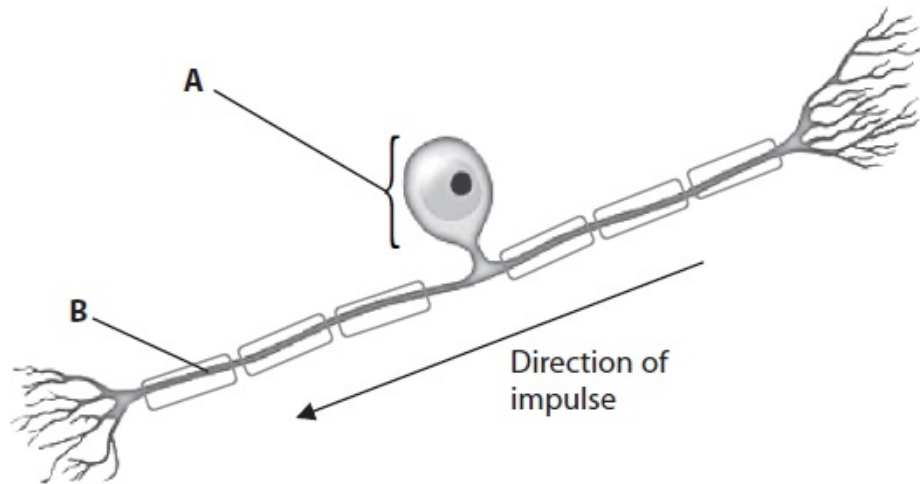
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Q24. The diagram below shows a sensory neurone.



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

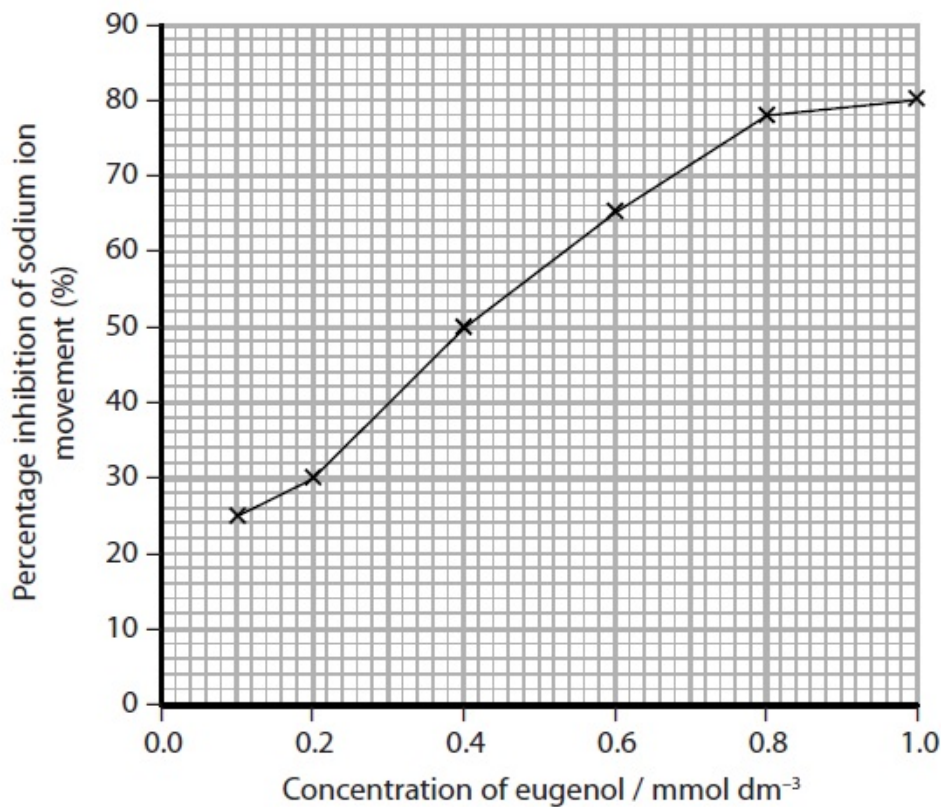
(2)

**A**.....

**B**.....

(b) Eugenol is a drug that inhibits the movement of sodium ions and calcium ions through the cell surface membranes of sensory neurones.

The graph below shows the effect of eugenol concentration on the percentage inhibition of sodium ion movement.



(i) Describe the relationship between the concentration of eugenol and the percentage inhibition of sodium ion movement.

(2)

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\*(ii) Eugenol can be used to reduce pain.

Suggest an explanation for how eugenol affects the movement of calcium ions and reduces pain.

(6)

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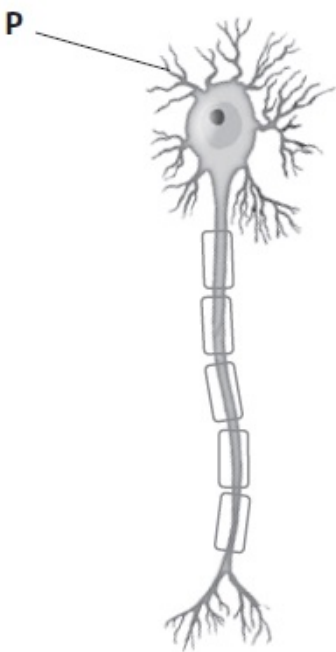
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**(Total for Question = 10 marks)**

Q25.        (a) The diagram below shows a motor neurone.



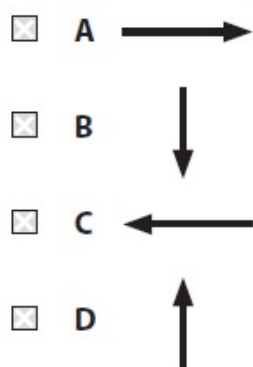
(i) Name the structure labelled **P**.

**(1)**

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(ii) Place a cross ☒ in the box to identify the direction of the nerve impulse in the axon of this motor neurone.

(1)



(b) Eugenol is a drug that inhibits the movement of sodium ions through the cell surface membranes of sensory neurones.

The table below shows the effect of eugenol concentration on the percentage inhibition of sodium ion movement.

| Concentration of eugenol<br>/ $\text{mmol dm}^{-3}$ | Percentage inhibition of sodium<br>ion movement (%) |
|-----------------------------------------------------|-----------------------------------------------------|
| 0.2                                                 | 30                                                  |
| 0.4                                                 | 50                                                  |
| 0.6                                                 | 65                                                  |
| 1.0                                                 | 80                                                  |

(i) Describe the effect of eugenol on the percentage inhibition of sodium ion movement.

(2)

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(ii) Using information from the table, calculate the percentage inhibition of sodium ion movement at a concentration of eugenol of  $0.8 \text{ mmol dm}^{-3}$ .

Show your working.

(2)

Answer.....%

\*(c) Eugenol can be used to reduce pain.

Suggest an explanation for how eugenol affects the movement of sodium ions and reduces pain.

(6)

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(Total for Question = 12 marks)

**Mark Scheme**

Q1.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                   | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | The only correct answer is <b>D</b> – all of his introns plus all of his exons<br><br><i><b>A</b> is incorrect because it does not describe the genome of the adult male</i><br><br><i><b>B</b> is incorrect because it does not describe the genome of the adult male</i><br><br><i><b>C</b> is incorrect because it does not describe the genome of the adult male</i> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <p>The only correct answer is <b>D</b> – yes for animal, bacterium and plant</p> <p><b>A</b> is incorrect because animals and bacteria can also be genetically modified and be a source of a gene</p> <p><b>B</b> is incorrect because animals can be genetically modified and be a source of a gene</p> <p><b>C</b> is incorrect because plants can be genetically modified and be a source of a gene</p> | (1)  |

Q2.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Additional Guidance                           | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------|
|                 | <p>A description that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>• (repeated stimulus) decreases {sensitivity / permeability} of pre-synaptic membrane / calcium channels not opening<br/>(1)</li> <li>• so {fewer / no} <math>\text{Ca}^{2+}</math> ions move into pre-synaptic neurone<br/>(1)</li> <li>• so {fewer / no} vesicles {move towards / fuse with} (pre-synaptic) membrane<br/>(1)</li> <li>• so {less / no} neurotransmitter {released / can diffuse across gap}<br/>(1)</li> <li>• {action potential / depolarisation} less likely to occur in post-synaptic neurone<br/>(1)</li> </ul> | ALLOW calcium channels less or not responsive | (4)  |

Q3.

| Question number | Answer                                                                                                                                                                                                                                                                           | Additional guidance                                                                                                                                                             | Mark                     |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
|                 | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>allows an animal (to learn) to ignore (repetitive) non-threatening stimuli (1)</li> <li>therefore allowing it to focus on (potentially) more relevant stimuli (1)</li> </ul> | <p>ALLOW therefore allowing it to conserve {energy / resources}</p> <p>ALLOW converse – such as if animals did not habituate they would waste energy on unimportant stimuli</p> | <p>Expert</p> <p>(2)</p> |

Q4.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (a)             | <ol style="list-style-type: none"> <li>reference to phytochrome ;</li> <li>idea that day length is the environmental cue ;</li> <li>reference to critical period / photoperiod ;</li> <li>this is more than 12 hours light / less than 12 hours darkness / eq ;</li> <li>idea that different wavelengths of light are involved</li> </ol> <p>OR</p> <p>reference to inter-conversion of phytochromes e.g. because light supplies red light which converts <math>P_R</math> converted to <math>P_{FR}</math> ;</p> <ol style="list-style-type: none"> <li>reference to florigen ;</li> </ol> |                     | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>Both</p> <ol style="list-style-type: none"> <li>1. chemicals ;</li> <li>2. produced in cells / eq ;</li> <li>3. idea that they move away from site of production ;</li> <li>4. effect may be distant from production site / eq ;</li> <li>5. long-term / permanent effect / example quoted / eq ;</li> <li>6. involved in gene activation /eq ;</li> </ol> | <ol style="list-style-type: none"> <li>5. ACCEPT both can control growth</li> <li>6. ACCEPT: Both can have an effect on gene inhibition</li> </ol> | (3)  |

| Question Number | Answer                                                                                                                                                                                 | Additional guidance | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)(ii)         | <ol style="list-style-type: none"> <li>1. idea that weeds affected because e.g. more sensitive, take up more ;</li> <li>2. idea that (auxin / IAA) causes cell elongation ;</li> </ol> |                     | (2)  |

Q5.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                         | Mark                     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
|                 | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• {IAA/auxin} is a (plant) hormone (1)</li> <li>• (investigation showed) cells grew longer with IAA / IAA stimulates cell elongation (1)</li> <li>• {light sensing / IAA producing} cells are in the tip (of the coleoptile) (1)</li> <li>• (results show) cell elongation happened in cells below the (shoot) tip (1)</li> <li>• the response to IAA is (relatively) {slow / prolonged} (1)</li> </ul> | <p>ALLOW IAA caused cell growth / increases cell length</p> <p>ALLOW cells that respond to IAA are in a different part of the coleoptile to the light sensing structures for MP 3 and 4</p> | <p>Expert</p> <p>(3)</p> |

Q6.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional guidance                                                                                                                                                                                                                                                                               | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|                 | <p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>• cytokine can bind to receptor on synaptic membrane (1)</li> <li>• effect on an ion channel (1)</li> <li>• therefore affecting the movement of ions across the membrane (1)</li> <li>• affecting the depolarisation of the membrane (1)</li> <li>• therefore affecting action potentials (in the neural circuit) (1)</li> </ul> | <p>ALLOW inhibitory or stimulatory effects</p> <p>ALLOW binds to acetylcholinesterase</p> <p>e.g. opens chloride ion channel</p> <p>ALLOW other described effects on membrane</p> <p>e.g. chloride ions moving in or potassium ions moving out</p> <p>e.g. threshold potential is not reached</p> | <p>(4)</p> |

Q7.

| Question number | Answer                                                                                                                                                                                                | Additional guidance                                                                                                                      | Mark                     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
|                 | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• use of {MRI / CT / PET} scans (1)</li> <li>• before treatment and after treatment (1)</li> </ul> | <p>ALLOW ultrasound scans / clinical investigation</p> <p>ALLOW regular scans / scans at stated frequency / over course of treatment</p> | <p>Expert</p> <p>(2)</p> |

Q8.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional Guidance                                                                                                                   | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------------|
|                 | <p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>• IAA diffuses from the tip of the coleoptile (1)</li> <li>• (therefore) can be taken up by cells in zone of elongation (1)</li> <li>• which causes cells to elongate (1)</li> <li>• details of action in zone of elongation (1)</li> <li>• (therefore) causes the coleoptile to { grow towards the light / increase in height } (1)</li> </ul> | <p>e.g. leads to lowering of the pH in the cellulose cell wall</p> <p>ALLOW: positive phototropism</p> <p>IGNORE: bend for growth</p> | <p>(4)</p> |

Q9.

| Question Number | Answer                                                                                                                                                                                                                                                                        | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <p><b>B</b> - X</p> <p><i>The only correct answer is <b>B</b></i></p> <p><i><b>A</b> is incorrect because W is a relay neurone</i></p> <p><i><b>C</b> is incorrect because Y is a motor neurone</i></p> <p><i><b>D</b> is incorrect because Z is a multipolar neurone</i></p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <p><b>D</b> - sugar molecules which are joined by glycosidic links</p> <p><i>The only correct answer is <b>D</b></i></p> <p><i><b>A</b> is incorrect because glycolipids are not made of amino acids</i></p> <p><i><b>B</b> is incorrect because glycolipids are not made of amino acids</i></p> <p><i><b>C</b> is incorrect because sugar molecules are not joined by ester bonds</i></p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                         | Additional Guidance | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (iii)           | <p>An answer that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• { form synapses / connections } with other neurones (1)</li> <li>• { integrate / receive } impulses from other neurones (1)</li> <li>• involved in summation</li> <li>• { propagate a signal / initiate an action potential } to the { cell body / axon }</li> </ul> |                     | (3)  |

Q10.

| Question Number | Answer                                                                                                                                                                                                                                                                                                   | Additional Guidance                                                                                                                                                                                                                          | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | 1. fMRI ;<br><br>and any two from:<br>2. (fMRI) operates in real time / eq ;<br><br>3. as experience will be short lived / eq ;<br><br>4. Active areas will {light up / be coloured / eq} (on the image) / eq ;<br><br>5. high resolution (as areas involved may be small) / eq ;<br><br>6. Safer / eq ; | <b>2 ACCEPT</b> live images, 4 images per second<br><br><b>4. ACCEPT</b> idea of active areas require more oxygen/ oxygenated blood<br><b>5 ACCEPT</b> more pixels, image is more detailed<br><b>6. ACCEPT</b> ref. to not using X rays, etc | (3)  |

| Question Number | Answer | Mark |
|-----------------|--------|------|
| (ii)            | D ;    | (1)  |

Q11.

| Question Number | Answer                                                                                                                                                | Additional Guidance | Mark                               |    |   |     |   |                                 |     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------|----|---|-----|---|---------------------------------|-----|
| (i)             | <table><tr><td>Type of scan</td><td>Can be used to identify the tumour</td></tr><tr><td>CT</td><td>✓</td></tr><tr><td>MRI</td><td>✓</td></tr></table> | Type of scan        | Can be used to identify the tumour | CT | ✓ | MRI | ✓ | DO NOT ACCEPT HYBRID tick/cross | (2) |
| Type of scan    | Can be used to identify the tumour                                                                                                                    |                     |                                    |    |   |     |   |                                 |     |
| CT              | ✓                                                                                                                                                     |                     |                                    |    |   |     |   |                                 |     |
| MRI             | ✓                                                                                                                                                     |                     |                                    |    |   |     |   |                                 |     |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <p>The only correct answer is A - blood flow</p> <p><i>B is incorrect because fMRI does not measure brain activity by detecting bone density</i></p> <p><i>C is incorrect because fMRI does not measure brain activity by detecting dopamine release</i></p> <p><i>D is incorrect because fMRI does not measure brain activity by detecting lactic acid production</i></p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                           | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (iii)           | <p>The only correct answer is A - CT</p> <p><i>B is incorrect because fMRI does not use X-rays</i></p> <p><i>C is incorrect because MRI does not use X-rays</i></p> <p><i>D is incorrect because PET does not use X-rays</i></p> | (1)  |

Q12.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>Reference to role of ions in</p> <ul style="list-style-type: none"> <li>• nerve conduction</li> <li>• release of neurotransmitters</li> <li>• muscle contraction</li> </ul> <p>Mention of</p> <ul style="list-style-type: none"> <li>• passive diffusion through ion channels</li> <li>• active transport against concentration gradients</li> </ul> <p>Examples of ion transport</p> <ul style="list-style-type: none"> <li>• active transport – sodium potassium pump</li> <li>• hydrogen ions in chemiosmosis</li> <li>• calcium channels in pre-synaptic knob</li> <li>• sodium and potassium channels in neurones</li> </ul> <p>Idea that ions moving down a concentration gradient can do work</p> <ul style="list-style-type: none"> <li>• ATP synthase in chemiosmosis</li> <li>• cotransporters</li> </ul> <p>Ion channels in disease</p> <ul style="list-style-type: none"> <li>• chloride channels in cystic fibrosis</li> <li>• credit any other sensible suggestions</li> <li>•</li> </ul> <p>Ideas around control</p> <ul style="list-style-type: none"> <li>• lots of different genes/proteins involved in transporting ions across membranes</li> <li>• specificity of channels for particular ions</li> <li>• control of opening and closing of different channels</li> </ul> | (9)  |

| Level | Marks |                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional Guidance                                                                                                                                                                    |
|-------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | 0     | No awardable content                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                        |
| 1     | 1-3   | <p>Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.</p> <p>Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.</p> | <p>simple description of data provided</p> <p>or</p> <p>discussion of one aspect from specification e.g. role of ions in action potentials / muscle contraction / mucus production</p> |
| 2     | 4-6   | <p>Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts.</p> <p>Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion shows some linkages and lines of scientific reasoning with some structure.</p>                                          | <p>Level 1 criteria plus</p> <p>discussion of another aspects from specification including consideration in {disease / ill-health} in at least one</p>                                 |
| 3     | 7-9   | <p>Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts.</p> <p>Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.</p>                                                                                                                            | <p>Level 2 criteria plus</p> <p>appropriate use of data from tables linked to health or disease</p> <p>or</p>                                                                          |

|  |  |                                                                                                                                  |                                                                                                                                                                                                                                                                         |
|--|--|----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  | <p>The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> | <p>attempt at higher level reasoning e.g explaining role of {ion gradients / active transport of ions} expanding on role of mutations in disease beyond cystic fibrosis / discussion of channel specificity or evolution of variety of channels with many functions</p> |
|--|--|----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Q13.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * (i)           | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>Indicative content</p> <p>from table:</p> <ul style="list-style-type: none"> <li>stimulated at just one point (V or W) – response lost after repeated stimulation</li> <li>if the repeated stimulation is alternated between two points (V and W) the worm still responds by contracting its muscles / no habituation when stimuli alternated between different locations</li> <li>different nerves / neurones / stimulated (by V and W)</li> </ul> <p>from diagrams:</p> <ul style="list-style-type: none"> <li>there is a response at X every time the neurone is stimulated</li> <li>{ repeated stimulation / after three stimuli } there is no longer an impulse recorded at Y</li> <li>electrode X is close to where the stimulus is applied and it detects an impulse each time</li> <li>electrode Y is further from where the stimulus is applied</li> <li>there is a synapse between the stimulus and the neurone monitored at Y</li> </ul> <p>Knowledge and understanding of habituation:</p> <ul style="list-style-type: none"> <li>after repeated stimulation the impulse cannot cross the synapse</li> <li>lack of neurotransmitter / not enough time to produce more neurotransmitter</li> <li>calcium ion channels not opening when impulse arrives at the synapse</li> <li>threshold not reached on the post-synaptic neurone and no action potential produced</li> </ul> |

| Level | Mark | Descriptor                                                                                                                                                                                                                                                                                                                                 | Additional Guidance                                                                                                                                                                                                                                           |
|-------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | 0    | No awardable content                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                               |
| 1     | 1-2  | Limited scientific judgement made with a focus on mainly just <b>one</b> study.<br><br>A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.                                                                             | One study focused on – probably the table of data<br><br>Idea of different nerves involved                                                                                                                                                                    |
| 2     | 3-4  | A scientific judgement is made through the application of relevant evidence from <b>both</b> studies.<br><br>A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.                                                             | Analysis refers to the table of data – idea of difference when stimulus at one place or alternating <b>and</b> the diagrams showing effects of stimulating nerves X and Y.<br><br>Links made to impulses not present post synapse and an explanation for that |
| 3     | 5-6  | A scientific judgement is made, which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information.<br><br>A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made. | Analysis of both studies <b>linked</b> to knowledge and understanding of habituation, <b>links</b> made to location of synapse and reasons why neurotransmitter not released.                                                                                 |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                                                                                                                                                                                                                          | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>description of suitable range of (at least five) frequencies (1)</li> <li>a method for making application of stimuli consistent / control of recovery time between tests (1)</li> <li>a method for checking for habituation in earthworms (1)</li> <li>repeats with other earthworms of same { species / size } (1)</li> </ul> | <p>ALLOW range of five different frequencies above and below 20 per minute</p> <p>e.g. (touch with a cotton bud) to same place each time<br/>e.g. give 2 minutes between each test</p> <p>e.g. observing for no response to touch / finding no change in length of earthworm</p> <p>(Maximum of 2 marks if investigation described in context of snails)</p> | (4)  |

Q14.

| Question number | Answer                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                      | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>• {immunise / infect} animals at different times during early development (1)</li> <li>• investigate animals later in life for { effects on learning / the development of neurological conditions } (1)</li> </ul> | <p>ALLOW compare animals with intact and with deficient (innate) immune systems</p> <p>ALLOW test animals' senses at different stages in development</p> | (2)  |

Q15.

| Question Number | Answer                                                                                                                                                                                                                                                                                                     | Additional Guidance                                              | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|------|
| (i)             | <p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>• time is required for heat to warm the blood (1)</li> <li>• because of the layer of insulation in the skin (1)</li> <li>• because it takes time for the warm blood to circulate (1)</li> </ul> | <p>ALLOW it takes time for warm blood to reach the fingertip</p> | (2)  |

| Question Number | Answer                                                                                                                                             | Additional Guidance                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <ul style="list-style-type: none"> <li>• maximum difference in temperature divided by time (1)</li> <li>• correct answer with units (1)</li> </ul> | <p>Example of calculation</p> <p><math>(32.0 - 27.5) \div 3</math></p> <p><math>1.5\text{ }^{\circ}\text{C min}^{-1}</math> OR <math>1.5\text{ }^{\circ}\text{C per minute}</math> OR <math>1.5\text{ }^{\circ}\text{C / minute}</math></p> <p>ALLOW <math>32.0 - 27.4</math> to give 1.53 for 2 marks</p> <p>Correct answer no working with units gains full marks</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Additional Guidance                                                                                                                                                                                                                                                                     | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (iii)           | <p>An explanation that makes reference to five of the following:</p> <ul style="list-style-type: none"> <li>• thermoreceptors detect increase in temperature (1)</li> <li>• description of role of hypothalamus in heat loss mechanism (1)</li> <li>• (therefore more) impulses are sent along the sympathetic { nerves / nervous system } (1)</li> <li>• which leads to constriction of shunt vessels (1)</li> <li>• therefore causing vasodilation (of arterioles) (1)</li> <li>• so more warm blood flows near the skin surface (1)</li> </ul> | <p>e.g. thermoreceptors in the hypothalamus detect temperature increase OR reference to role of heat loss centre / thermoregulatory centre in co-ordinating mechanisms of heat loss</p> <p>ALLOW so more warm blood in capillaries<br/>ALLOW radiation of heat energy from the skin</p> | (5)  |

Q16.

| Question Number | Answer              | Additional Guidance | Mark       |
|-----------------|---------------------|---------------------|------------|
| <b>(a)</b>      | C<br>(phospholipid) |                     | <b>(1)</b> |

| Question Number | Acceptable Answer | Additional Guidance | Mark       |
|-----------------|-------------------|---------------------|------------|
| <b>(b)(i)</b>   | rhodopsin         |                     | <b>(1)</b> |

| Question Number | Acceptable Answer | Additional Guidance | Mark       |
|-----------------|-------------------|---------------------|------------|
| <b>(b)(ii)</b>  | (cis) retinal     |                     | <b>(1)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                             | Additional Guidance | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(c)</b>      | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>opsin released causing sodium ion channels to be blocked (1)</li> <li>which causes hyperpolarisation in the rod cell (1)</li> <li>causing action potential in bipolar cell (results in action potential in the optic nerve) (1)</li> </ul> |                     | <b>(3)</b> |

Q17.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                          | Additional guidance                                                                                                        | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>A description that makes reference to two of the following points:</p> <ul style="list-style-type: none"> <li>serotonin is a neurotransmitter / there will be less neurotransmitter (1)</li> <li>(less serotonin) results in fewer depolarisations of post synaptic membranes (1)</li> <li>threshold not achieved / less chance of action potential being produced (in post-synaptic neurone) (1)</li> </ul> | <p>ALLOW no serotonin or no neurotransmitter</p> <p>ALLOW no depolarisations</p> <p>ALLOW no action potential produced</p> | (2)  |

Q18.

| Question Number | Acceptable Answer | Additional Guidance | Mark       |
|-----------------|-------------------|---------------------|------------|
| <b>(a)</b>      | B                 |                     | <b>(1)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                              | Additional Guidance | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(b)</b>      | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>MRI gives better resolution (1)</li> <li>therefore more detail can be seen (1)</li> <li>no use of X-rays (1)</li> <li>therefore {safer / less risk of mutation / eq} (1)</li> <li>therefore can be used more often (1)</li> </ul> |                     | <b>(3)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                     | Additional Guidance | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(c)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>increased neural activity of {cerebellum / cerebrum} (1)</li> <li>more oxygen needed so increase in {blood flow / oxyhaemoglobin} (1)</li> <li>less {radio wave / signal} absorbed (1)</li> </ul> |                     | <b>(3)</b> |

Q19.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional guidance                                                                                                                                                                                                                                                                | Mark                              |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
|                 | <p>A description that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>extract mRNA for one form of the (tau protein) (1)</li> <li>copy mRNA into DNA (1)</li> <li>use restriction enzymes {to create sticky ends} / cut the DNA and a vector (1)</li> <li>{ligate / insert / integrate} the TAU DNA into the vector (DNA) (1)</li> <li>introduce vector into {fertilised egg / embryonic stem / zygote / cells / neural cell stem cells} (1)</li> </ul> | <p>IGNORE cut / remove TAU gene from a human</p> <p>ALLOW synthesis DNA sequence for one form e.g. use code specific for one of the tau proteins</p> <p>ALLOW insert gene into fertilised egg cell / embryonic stem cell</p> <p>ALLOW egg cell fertilised after inserting gene</p> | <p>Choose an item.</p> <p>(4)</p> |

Q20.

| Question Number | Acceptable Answer                                                                                                        | Additional Guidance | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(a)</b>      | <ul style="list-style-type: none"> <li>Idea that {cell body / centron} in middle / dendrites at both ends (1)</li> </ul> |                     | <b>(1)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Additional Guidance | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(b)</b>      | <p>An explanation that makes reference to five of the following:</p> <ul style="list-style-type: none"> <li>reference to Schwann cells covering the axon in myelinated neurone (1)</li> <li>{myelin/Schwann cells} provide insulation (1)</li> <li>{action potential/depolarisation} at nodes of Ranvier (1)</li> <li>local currents occur over a longer distance (1)</li> <li>reference to saltatory conduction (1)</li> <li>impulse jumps from node to node (1)</li> </ul> |                     | <b>(5)</b> |

Q21.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional Guidance                                                                                                                                                   | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <ol style="list-style-type: none"> <li>1. identical twins (agreement) is greater / eq ;</li> <li>2. credit correct manipulation of the data e. g. {41% more / 2.4x as much / 141% higher / eq} agreement than non-identical twins ;</li> <li>3. idea that alleles are involved ;</li> <li>4. idea that non-identical have genetic differences ;</li> <li>5. idea that because less than 100% then some other factor is involved ;</li> </ol> | <p>ACCEPT converse where appropriate</p> <p>2. ACCEPT 41% difference</p> <p>3. ACCEPT gene alternatives</p> <p>4. ACCEPT identical twins are genetically the same</p> | (4)  |

| Question Number | Answer                                                 | Additional Guidance                                                                                                               | Mark |
|-----------------|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | idea that there is less of a gap between the results ; | ACCEPT expressed as numbers, results similar (to each other), identical twin result is lower, non-identical twin result is higher | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional Guidance                                                                                                                                                                                                                                                                              | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <ol style="list-style-type: none"> <li>1. idea that active areas have more {oxygen / oxygenated blood} ;</li> <li>2. active areas involved in face recognition will be identified / eq ;</li> <li>3. idea of level of brain activity between identical twins and non identical twins is compared ;</li> <li>4. to offer supportive evidence / improve validity of study ;</li> <li>5. idea that fMRI shows brain activity in real time ;</li> <li>6. idea of high resolution ;</li> <li>7. comment on safety / eq ;</li> </ol> | <p>3. ACCEPT idea of {areas more active / more oxygenated blood flowing to areas} in identical twins compared with non-identical twins</p> <p>3. ACCEPT idea of {more / eq} areas showing activity in common in identical twins than non-identical</p> <p>7. ACCEPT fMRI does not use X rays</p> | (4)  |

Q22.

| Question Number | Answer     | Mark       |
|-----------------|------------|------------|
| <b>(a)(i)</b>   | 100 (mV) ; | <b>(1)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Mark                                |   |                                     |   |                                     |   |   |                                                                           |  |  |                                     |  |  |  |                                           |  |  |  |  |                                     |  |                                    |                                     |  |  |  |  |  |     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---|-------------------------------------|---|-------------------------------------|---|---|---------------------------------------------------------------------------|--|--|-------------------------------------|--|--|--|-------------------------------------------|--|--|--|--|-------------------------------------|--|------------------------------------|-------------------------------------|--|--|--|--|--|-----|
| (a)(ii)         | <table><tr><th>Description</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr><tr><td>Stage when the concentration of positive ions is greatest inside the axon</td><td></td><td></td><td><input checked="" type="checkbox"/></td><td></td><td></td><td></td></tr><tr><td>Stage when hyperpolarisation first occurs</td><td></td><td></td><td></td><td></td><td><input checked="" type="checkbox"/></td><td></td></tr><tr><td>Site showing the resting potential</td><td><input checked="" type="checkbox"/></td><td></td><td></td><td></td><td></td><td></td></tr></table> | Description                         | A | B                                   | C | D                                   | E | F | Stage when the concentration of positive ions is greatest inside the axon |  |  | <input checked="" type="checkbox"/> |  |  |  | Stage when hyperpolarisation first occurs |  |  |  |  | <input checked="" type="checkbox"/> |  | Site showing the resting potential | <input checked="" type="checkbox"/> |  |  |  |  |  | (3) |
|                 | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | A                                   | B | C                                   | D | E                                   | F |   |                                                                           |  |  |                                     |  |  |  |                                           |  |  |  |  |                                     |  |                                    |                                     |  |  |  |  |  |     |
|                 | Stage when the concentration of positive ions is greatest inside the axon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                     |   | <input checked="" type="checkbox"/> |   |                                     |   |   |                                                                           |  |  |                                     |  |  |  |                                           |  |  |  |  |                                     |  |                                    |                                     |  |  |  |  |  |     |
|                 | Stage when hyperpolarisation first occurs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                     |   |                                     |   | <input checked="" type="checkbox"/> |   |   |                                                                           |  |  |                                     |  |  |  |                                           |  |  |  |  |                                     |  |                                    |                                     |  |  |  |  |  |     |
|                 | Site showing the resting potential                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <input checked="" type="checkbox"/> |   |                                     |   |                                     |   |   |                                                                           |  |  |                                     |  |  |  |                                           |  |  |  |  |                                     |  |                                    |                                     |  |  |  |  |  |     |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>*(b)</b>     | <p>QWC – Spelling of technical terms (<i>shown in italics</i>) must be correct and the answer must be organised in a logical sequence</p> <ol style="list-style-type: none"> <li>1. diffuses across {gap /eq} ;</li> <li>2. binds to (receptors on) post-synaptic membrane / eq ;</li> <li>3. idea of gated-channels opening or <math>\text{Na}^+</math> travels through post-synaptic membrane ;</li> <li>4. causing a depolarisation / eq ;</li> <li>5. (if sufficient present) an action potential is set up in {post-synaptic membrane/adjacent cell / eq} ;</li> <li>6. details such as temporal or spatial summation ;</li> <li>7. idea that allows coordination / one way flow of information ;</li> <li>8. idea that it allows integration in post-synaptic cell ;</li> <li>9. neurotransmitter broken down (by enzyme) / eq ;</li> <li>10. so that do not get {prolonged /eq} action potential in post-synaptic membrane / make receptors available again ;</li> <li>11. credit reference to fate of products e.g. reabsorbed through pre-synaptic membrane OR to be re-synthesised into neurotransmitter substance ;</li> </ol> | <b>(5)</b> |

Q23.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Mark                           |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
|                 | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>frequency is {the same / similar} for all flies at 10 days (1)</li> <li>for older flies with {0N4R the error bars overlap with the control (1)</li> <li>therefore 0N4R has {no / little} effect on the frequency of impulses (1)</li> <li>for older flies 0N3R the error bars do not overlap with the control } (1)</li> <li>therefore 0N3R decreases the frequency of impulses (1)</li> </ul> | <p>ALLOW length of time between impulses</p> <p>ALLOW frequency decreases from 220 to 190 impulses per second</p> <p>ALLOW length of time between impulses<br/>IGNORE unqualified length of time / increase</p> <p>ALLOW frequency decreased from 227 to 137 impulses per second</p> <p>ALLOW more significant / greatest effect ALLOW length of time between impulses IGNORE unqualified length of time / increase</p> <p>ALLOW effect was greater in older flies if MP2 to 5 not awarded</p> | <p>Choose an item.<br/>(4)</p> |

Q24.

| Question Number | Answer                                      | Additional guidance | Mark       |
|-----------------|---------------------------------------------|---------------------|------------|
| <b>(a)</b>      | <b>A</b> - cell body ;<br><b>B</b> - axon ; |                     | <b>(2)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                    | Additional guidance                                                                                                   | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|------------|
| <b>(b)(i)</b>   | 1. increasing Eugenol concentration increases percentage inhibition / positive correlation ;<br><br>2. description of non linear correlation ;<br><br>3. credit correct manipulation of the data e.g. between 0.1 and 1.0 mmol dm <sup>3</sup> percentage inhibition to increase by 55% ; | ACCEPT 2 – e.g. greatest increase in inhibition is between eugenol concentration of 0.2 and 0.4 mmol dm <sup>-3</sup> | <b>(2)</b> |

| Question Number  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                                                                                                  | Mark       |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>* (b)(ii)</b> | QWC – Spelling of technical terms ( <i>shown in italics</i> ) must be correct and the answer must be organised in a logical sequence)<br><br>1. {reduced / eq} Ca <sup>2+</sup> enters { <i>presynaptic membrane</i> / into <i>sensory neurone</i> } ;<br><br>2. due to Ca <sup>2+</sup> channel not opening / decreased sensitivity of <i>membrane</i> to Ca <sup>2+</sup> ;<br><br>3. fewer <i>vesicles</i> {move towards / fuse} with <i>presynaptic membrane</i> ;<br><br>4. less <i>neurotransmitter</i> {released into / less diffuses across} { <i>synaptic gap</i> / eq} ;<br><br>5. less <i>neurotransmitter</i> binds to receptors on { <i>post-synaptic membrane</i> / adjacent neurone} ;<br><br>6. idea of reduced depolarisation / less Na <sup>+</sup> or cation channels open ;<br><br>7. idea of { threshold intensity / <i>action potential</i> / <i>impulse</i> } less likely to occur ;<br><br>8. idea of pain not being sensed as impulse {stopped before entering CNS / leaving the <i>sensory neurone</i> } ; | ACCEPT 1 – into <i>synaptic knob</i> / pre-synaptic neurone<br><br><br><br><br><br><br>ACCEPT 4 (& 5) - named neurotransmitter example<br><br><br><br><br><br><br>ACCEPT 7 - not reached as alternative to less likely to be reached | <b>(6)</b> |

Q25.



Q1.

The nervous system is made up of many different neurones including those involved in reflex actions.

(a) The table below shows features of three types of neurone in a spinal reflex. Place a cross ☒ in the box if the feature is present in any of the named neurones.

(4)

| Feature                                                       | Type of neurone                     |                                     |                                     |
|---------------------------------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
|                                                               | Sensory                             | Relay                               | Motor                               |
| Found only in the central nervous system                      | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Cell terminates at the effector                               | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Pre-synaptic membrane not found in the central nervous system | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Impulse stimulated by the receptor                            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

(b) Rod cells and muscle cells in the eye both require ATP

(i) Name the chemical reaction that occurs when ATP is broken down.

(1)

.....

(ii) Describe the function of ATP in a rod cell soon after a person has moved from an area of bright light to an area of low light.

(2)

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(iii) Describe the role of ATP in the contraction of a muscle fibre.

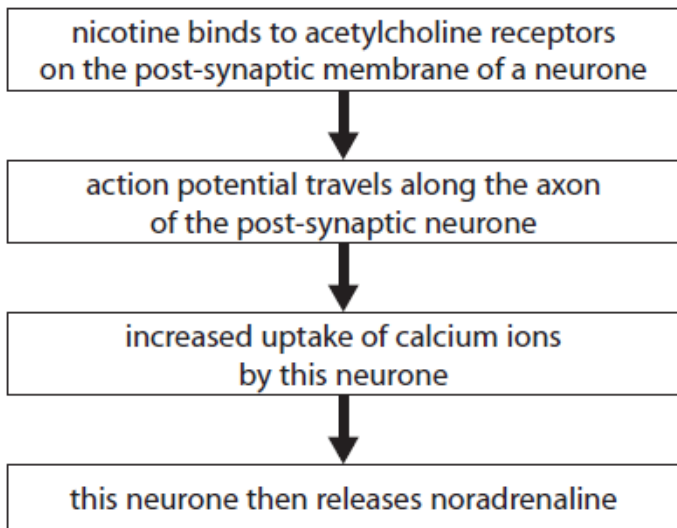
(5)

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**(Total for question = 12 marks)**

The flow diagram shows how the presence of nicotine can cause the release of noradrenaline.



(i) Explain how nicotine causes an action potential in the post-synaptic neurone that releases noradrenaline.

(3)

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(ii) State how an increase in calcium ion uptake by the neurone leads to the release of noradrenaline.

(1)

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**(Total for question = 4 marks)**

Q3. The scientific article you have studied is adapted from several sources.

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

(a) The sweet potato eaten by naked mole rats (paragraph 3) is very rich in starch. Starch can be a combination of amylose and amylopectin.

Give **two** structural differences between amylose and amylopectin.

(2)

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(b) Explain why a colony of naked mole rats is considered 'a eusocial society' (paragraph 4).

(2)

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(c) Naked mole rats show evidence of poikilothermy (paragraph 5).

(i) Explain what is meant by the term **poikilothermic**.

(1)

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(ii) Suggest how each of the following 'contribute to poikilothermic responses to changing temperature of this mammal'.

(2)

'Lack of an insulating layer'

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'A marked reduction in sweat glands'

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Touching something hot, which could lead to a burn, can cause nerve impulses to travel along myelinated sensory neurones very rapidly.

[illegible]

(f) Explain how a heart attack can temporarily reduce the oxygen concentration in brain tissue (paragraph 36).

(3)

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(g) Using the information in paragraph 48, name **one** hormone **and** state its function.

(1)

Hormone:

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Function:

.....

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(h) Suggest how a change in the mid region of the sperm may make it non-motile (paragraph 48).

(2)

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(i) Disperser naked mole rats 'are laden with fat' (paragraph 50).

Suggest why it may be advantageous for disperser naked mole rats to have high levels of fat.

(3)

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(j) Explain the statement that 'a preference by reproductively active females for unfamiliar males is interpreted as inbreeding avoidance' (paragraph 52).

(2)

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(k) 'The naked mole rat hasn't yet had its genome sequenced' (paragraph 53).

Explain what is meant by the term **genome sequenced**.

(1)

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(l) 'With so much to offer science, it is no surprise that naked mole rats are becoming more common in labs' (paragraph 53).

Using information from the article, describe **two** adaptations of naked mole rats. For each adaptation, explain why it could be of interest in a medical research laboratory.

(4)

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**(Total for Question = 30 marks)**

Q4.

The scientific article you have studied is from *Scientific American*.

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

'Most drugs cannot easily penetrate the brain' (paragraph 3).

Explain how the treatment of Parkinson's disease overcomes the difficulty of drugs passing from the blood into the brain.

**(2)**

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**(Total for question = 2 marks)**

Q5.

Both plants and animals are able to respond to stimuli using photosensitive pigments.

(a) The photosensitive pigment in plants can be involved in a range of responses to environmental cues. This includes flower production in response to day length.

The diagram below shows the results of a study on the effect of day length on flowering in one species of plant.

|       |      |       |       |       |                      |
|-------|------|-------|-------|-------|----------------------|
| 0 hr  | 6 hr | 12 hr | 18 hr | 24 hr | Flowers are produced |
| Light |      |       |       | Dark  | Yes                  |
| 0 hr  | 6 hr | 12 hr | 18 hr | 24 hr |                      |
| Light |      |       | Dark  |       | Yes                  |
| 0 hr  | 6 hr | 12 hr | 18 hr | 24 hr |                      |
| Light |      | Dark  |       |       | No                   |
| 0 hr  | 6 hr | 12 hr | 18 hr | 24 hr |                      |
| Light |      | Dark  |       |       | No                   |

(i) Place a cross ☒ in the box to complete the conclusion made using these results.

The critical amount of daylight needed for the production of flowers is

(1)

- ☐ **A** between 15 and 18 hours
- ☐ **B** between 12 and 15 hours
- ☐ **C** between 9 and 12 hours
- ☐ **D** between 6 and 9 hours

(ii) The photosensitive pigment involved in making this plant species produce flowers is likely to be

(1)

- ☐ **A** IAA
- ☐ **B** chlorophyll

☐ **C** FAD

☐ **D** phytochrome

(iii) Suggest how the plants were grown to ensure this study was valid.

(2)

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(iv) Suggest how this study could be changed to produce a more accurate conclusion.

(1)

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(b) For some plant species, day length is not an environmental cue for the production of flowers.

Suggest **one** environmental cue, other than day length, that could stimulate plants of these species to produce flowers.

(1)

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(c) Rhodospin is found in rod cells in the retina of mammalian eyes.

(i) State the location of rhodopsin within a rod cell.

(1)

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(ii) In the table below, place a tick (✓) in the box if the statement applies to the description and place a cross (✗) in the box if the statement does not apply.

(3)

| Description                   | Statement                            |                    |          |
|-------------------------------|--------------------------------------|--------------------|----------|
|                               | Opsin binds to the rod cell membrane | Rhodopsin bleaches | ATP used |
| Rhodopsin responding to light |                                      |                    |          |
| Rhodopsin being reformed      |                                      |                    |          |

(Total for question = 10 marks)

Q6.

An experiment was carried out to investigate mineral deficiencies on the growth of seedlings.

The effects of two mineral deficiencies on two different species of plant were investigated.

Test tubes were half filled with an aqueous gel containing a mineral solution without calcium ions. Seeds of rice or fenugreek were placed separately in these test tubes.

These test tubes were placed by a window for two weeks to allow the seeds to germinate and the seedlings to grow.

This was repeated using test tubes containing mineral solution without magnesium ions.

The only source of light provided for the plants was from outside the window. All of the seedlings grew towards the window.

Explain the reason for this response of these seedlings to light.

(3)

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Q7.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Phytochromes and IAA (indole acetic acid) are important substances that bring about growth responses in plants.

Phytochrome is found in two different forms known as  $P_R$  (or  $P_{660}$ ) and  $P_{FR}$  (or  $P_{730}$ ).

(i) Which row correctly describes the effects of sunlight on phytochrome?

(1)

|                            | Change in form of phytochrome | Speed of change |
|----------------------------|-------------------------------|-----------------|
| <input type="checkbox"/> A | $P_{FR}$ to $P_R$             | slow            |
| <input type="checkbox"/> B | $P_{FR}$ to $P_R$             | rapid           |
| <input type="checkbox"/> C | $P_R$ to $P_{FR}$             | slow            |
| <input type="checkbox"/> D | $P_R$ to $P_{FR}$             | rapid           |

(ii) Phytochrome can be described as

(1)

- ☐ A a form of opsin
- ☐ B a photosensitive pigment
- ☐ C an isomer of retinal
- ☐ D a type of cytochrome

(iii) Give one example of a growth response of a plant that is affected by phytochrome.

(1)

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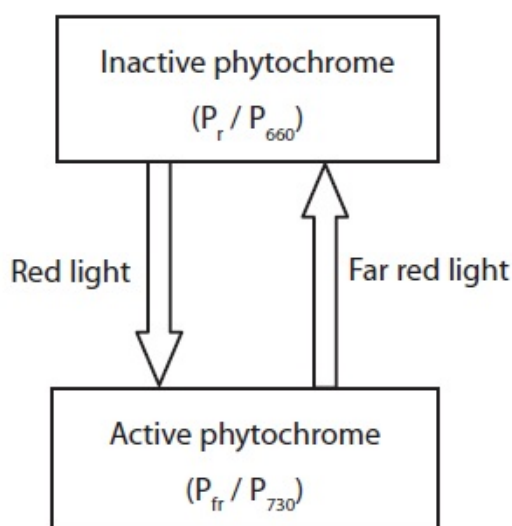
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(Total for question = 3 marks)

Q8.

Phytochromes are photoreceptors found in many plants.

(a) The diagram below shows the interconversion of inactive phytochrome ( $P_r / P_{660}$ ) and active phytochrome ( $P_{fr} / P_{730}$ ).



State **one** way in which the active form of phytochrome can be converted back to the inactive form, other than by exposing it to far red light.

(1)

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(b) A study was carried out to investigate the effect of red light and far red light on sunflower plants.



A sunflower  
Magnification  $\times 0.5$

One group of sunflower seedlings, group A, was grown under a lamp that emitted red light and far red light of the same intensity.

Another group of sunflower seedlings, group B, was grown in the same way, except that the lamp emitted a lower intensity of red light. The intensity of far red light was unchanged.

When the plants were fully grown, the mean dry mass of the flowers produced and the mean length of the plant stems were recorded.

This study was repeated using new groups of sunflower seedlings.

The results are shown in the table below.

| Study    | Mean dry mass of the flowers / g |         | Mean stem length / cm |         |
|----------|----------------------------------|---------|-----------------------|---------|
|          | Group A                          | Group B | Group A               | Group B |
| Original | 58                               | 45      | 125                   | 148     |
| Repeat   | 43                               | 38      | 124                   | 142     |

(i) Using the mean dry mass of the flowers shown in the table, compare the results of group A with group B for both the original and repeat studies.

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(ii) The light conditions experienced by group B were similar to those found near ground level in woodland.

Using the mean stem lengths shown in the table, suggest the importance of these light conditions for a young seedling in the woodland.

(3)

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(iii) A statistical analysis of the data for mean stem length was carried out.

The analysis showed that there was a significant difference between the mean stem length data for groups A and B. However, there was no significant difference between the data from the original study and the repeat study.

Suggest a conclusion for the effect of light on mean stem length and use the results of this statistical analysis to comment on the reliability of the data.

(3)

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**(Total for question = 10 marks)**

Q9.

The response of an animal to a stimulus can change if the stimulus is repeated.

The photograph shows the head and part of the body of a marine worm that lives in a chalky tube.



© Johnner Images / Alamy

The worm moves its head out of the tube to feed. The worm will withdraw into its tube if it senses danger and any change in length of the worm can be measured.

An investigation was carried out to study the response of ten worms to a moving shadow and to touch. Five of the worms were kept in their tubes and the other five were removed from their tubes. A shadow was moved over the worms and the decrease in length of each worm was recorded.

The investigation was repeated with another 10 worms but the stimulus used was touch instead of a moving shadow.

The results are shown in the table below.

| Worms       | Mean decrease in length / cm |       |
|-------------|------------------------------|-------|
|             | Moving shadow                | Touch |
| In tube     | 1.08                         | 2.03  |
| Not in tube | 0.01                         | 1.53  |

(a) Calculate the percentage difference in the response of the worms to touch.

(2)

Answer .....

(b) Analyse the data to explain the difference in the withdrawal response of the worms to the different stimuli.

(3)

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(c) When the touch stimulus is applied several times to the worms, they learn to reduce the withdrawal response.

(i) Give **two** advantages for worms with this type of learning behaviour.

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(ii) Explain how repeated touch stimulation reduces the withdrawal response.

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**(Total for question = 12 marks)**

Q10.

The scientific article you have studied is from *Scientific American*.

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

Describe how bacteria can be genetically modified to produce a cytokine for the treatment of neurological and mental disorders (paragraph 24).

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**(Total for question = 4 marks)**

Q11.

The scientific article you have studied is adapted from 'How Performance-Enhancing Drugs

Work.'

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

(a) (i) The population of the UK is 63 182 000 of which 49 182 000 are adults (paragraph 13).

Calculate the number of adults who have asthma.

(2)

Answer .....

(ii) People with asthma sometimes have difficulty breathing (paragraph 13).

Explain how beta-2 agonists may help to relieve their symptoms.

(2)

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(iii) Explain how beta-2 agonists can increase the heart rate (paragraph 13).

(4)

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(b) Explain how human growth hormone (HGH) is able to stimulate cells to secrete IGF-1 (paragraphs 20 and 21).

(4)

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(c) Explain why it is difficult to identify athletes who are using banned substances such as HGH (paragraphs 17, 20 and 22).

(2)

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(d) Explain one benefit of using substances developed from perfluorocarbons (PFCs) to treat patients with breathing difficulties (paragraphs 30 and 31).

(2)

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(e) Local anaesthetics mask pain by binding to protein channels in the membranes of neurones (paragraph 38).

Explain how binding to protein channels will prevent pain being sensed by the pain centre of the brain.

(4)

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(f) Explain why diuretics are a prescribed drug for high blood pressure (paragraph 43).

(2)

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(g) A test for the T/E ratio can help to identify athletes who have injected testosterone into their body (paragraph 45).

Explain the limitation of this test.

(3)

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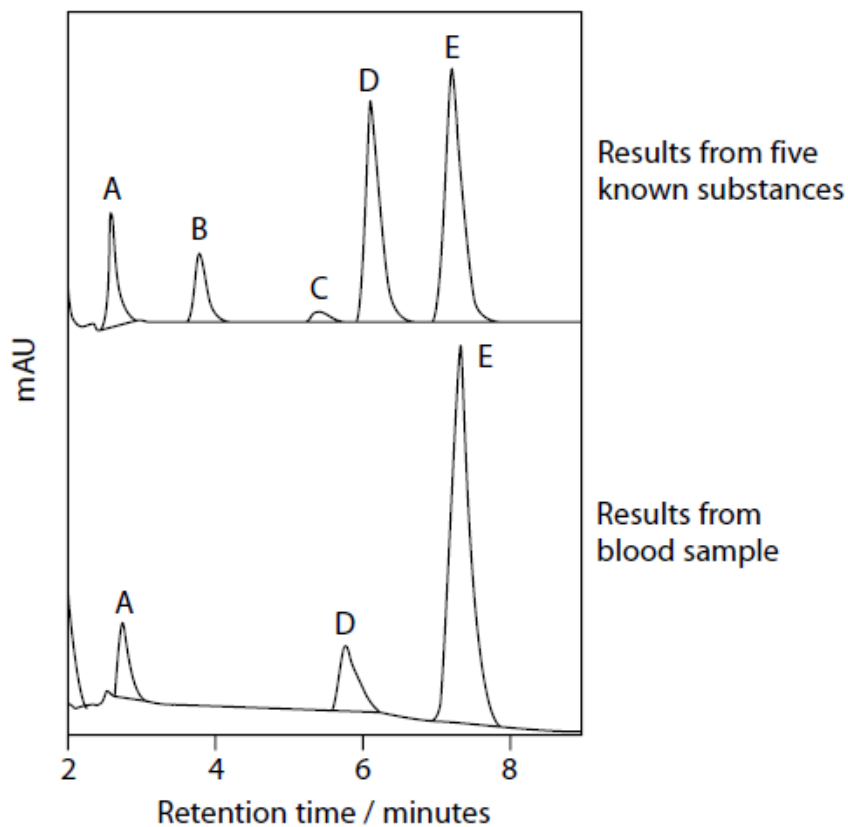
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(h) Gas chromatography (GC) can be used to detect athletes who have taken banned drugs (paragraph 48).

The chromatogram shows the GC results for five known banned substances, A, B, C, D and E.



Explain why the peak for drug E is different from the peak for drug A (paragraph 48).

(2)

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(i) Explain how the blood passport may result in more effective monitoring of athletes (paragraph 51).

(2)

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(j) Comment on the ethical viewpoints for and against the use of performance-enhancing drugs by athletes.

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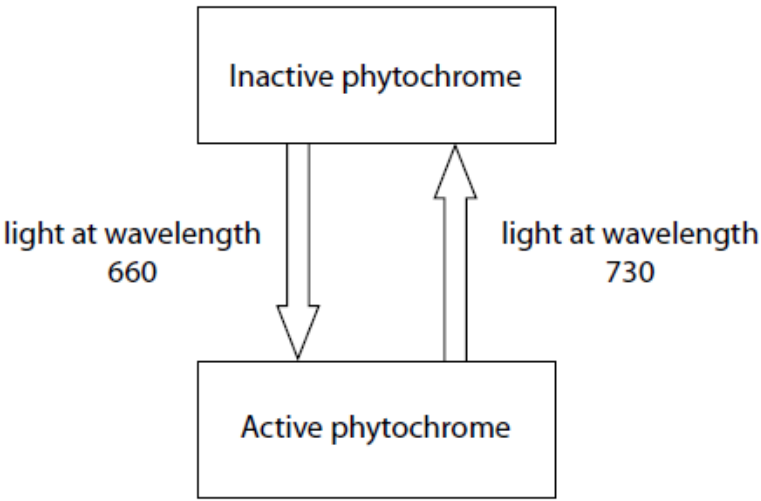
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**(Total for question = 33 marks)**

Q12.

Phytochromes are photoreceptors found in many plants.

The diagram below shows the interconversion of inactive phytochrome (Pr / P660) and active phytochrome (Pfr / P730).



Which row of the table correctly shows the light conditions that convert the active form of phytochrome back to the inactive form?

(1)

| Light condition            |                      |                          |                     |
|----------------------------|----------------------|--------------------------|---------------------|
|                            | exposed to red light | exposed to far red light | exposed to darkness |
| <input type="checkbox"/> A | yes                  | no                       | yes                 |
| <input type="checkbox"/> B | no                   | yes                      | no                  |
| <input type="checkbox"/> C | no                   | yes                      | yes                 |
| <input type="checkbox"/> D | yes                  | no                       | no                  |

(Total for question = 1 mark)

Q13. Rod cells in the eye are linked to the brain by neurones.

(a) Place a cross in the box ☐ to identify the answer that correctly completes each statement.

(i) The pigment in a rod cell is made of opsin and

(1)

- ☐ A retina
- ☐ B retinal
- ☐ C retine
- ☐ D retinol

(ii) When light stimulates a rod cell the pigment changes. This pigment is

(1)

- ☐ A iodopsin
- ☐ B phytochrome far red
- ☐ C phytochrome red
- ☐ D rhodopsin

(iii) Once the pigment has changed, the concentration of sodium ions inside the rod cell

(1)

- ☐ **A** decreases
- ☐ **B** does not change
- ☐ **C** increases
- ☐ **D** reaches equilibrium with the outside of the cell

(iv) After changing, the pigment takes time to become functional again. This is because

**(1)**

- ☐ **A** it has to bleach
- ☐ **B** the membrane has to be polarised
- ☐ **C** the rod cell needs to reset
- ☐ **D** two components have to be rejoined

(v) The cell that links a rod cell to a sensory neurone is

**(1)**

- ☐ **A** a bipolar neurone
- ☐ **B** a multipolar neurone
- ☐ **C** a unipolar neurone
- ☐ **D** an optic nerve

(b) Decreasing the intensity of light entering the eye causes pupil dilation. Describe the roles of the circular and radial muscles in pupil dilation.

**(2)**

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**(Total for Question = 7 marks)**

Spider silk is a very strong and flexible natural fibre. It is of interest to humans as a possible fibre for protective clothing.

Scientists have genetically modified a range of organisms to produce spider silk, including goats and plants such as alfalfa.

Give two reasons why some people may be concerned about the use of genetically modified alfalfa as a source of spider silk.

(2)

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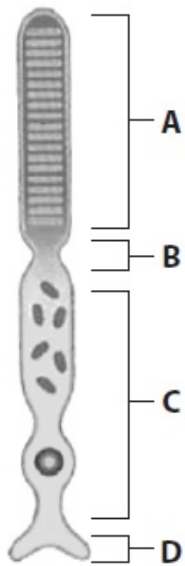
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(Total for question = 2 marks)

Q15. The retina of the eye is sensitive to light. It contains rod cells.

The diagram below shows a rod cell. Parts of this cell are labelled **A**, **B**, **C** and **D**.



(a) The table below gives three descriptions of parts of the rod cell. Place a cross ☒ in the box to identify the part of the rod cell described.

(3)

| Description                           | Part of the rod cell                |                                     |                                     |                                     |
|---------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
|                                       | A                                   | B                                   | C                                   | D                                   |
| Nearest the pupil of the eye          | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Containing the photosensitive pigment | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Has a pre-synaptic membrane           | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

(b) When light reaches a rod cell the voltage across the cell surface membrane can change. This can lead to the formation of an action potential in an optic neurone.

(i) Describe how light causes a change in the voltage across the cell surface membrane of a rod cell.

(4)

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(ii) Suggest why a change in voltage across the cell surface membrane of a rod cell may not lead to the formation of an action potential in an optic neurone.

(2)

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**(Total for Question = 9 marks)**

Q16.

Humans have a nervous system that has a variety of neurones.

The human brain is made up of a number of areas containing many millions of neurones.

Place a cross in the box ☒ that identifies the areas of the brain associated with riding a bicycle uphill.

(i) the decision to ride the bicycle

(1)

- ☐ **A** cerebrum
- ☐ **B** cerebellum
- ☐ **C** hypothalamus
- ☐ **D** medulla

(ii) initiating an increase in sweating during the ride

(1)

- ☐ **A** cerebrum

- ☐ **B** cerebellum
- ☐ **C** hypothalamus
- ☐ **D** medulla

Q17.

The scientific article you have studied is adapted from the book called The Immortal Life of Henrietta Lacks by Rebecca Skloot. Published by Pan Books in 2011.

(a) Explain what is meant by the term **mitosis** (paragraph 7).

(2)

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(b) The genome makes sure that cells 'do their jobs, whether that's controlling your heartbeat or helping your brain understand the words on this page' (paragraph 10).

Describe how cells in the sino-atrial node (SAN) are involved in controlling heart rate.

(3)

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(c) Henrietta's cells have 'been used to study lactose digestion' (paragraph 16).

Suggest how her cells may have digested lactose.

(3)

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(d) 'Like guinea pigs and mice, Henrietta's cells have become the standard laboratory workhorse' (paragraph 16).

Suggest **two** reasons why it is preferable to use Henrietta's cells in medical research, rather than using guinea pigs and mice.

(2)

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\*(e) 'By the end of 1951, the world was in the midst of the biggest polio epidemic in history' (paragraph 19). This was caused by poliovirus which can lead to paralysis (paragraph 20).

The virus infects motor neurones which can stop skeletal muscles from working.

Suggest how an infection of motor neurones by the virus can stop the transmission of nerve impulses and lead to muscle paralysis.

(6)

(f) Poliovirus, like Human Immunodeficiency Virus, is a retrovirus. Poliovirus was able to infect HeLa cells (paragraph 25).

(3)

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(g) Scientists had studied genes by breeding plants 'then breeding their offspring to see how genetic traits are passed from one generation to the next' (paragraph 33).

When this was done using a smooth pea and a wrinkled pea, it was found that in the F2 generation (second generation of offspring), 75% were smooth.

In the space below, draw genetic diagrams to describe and explain the genotypes of the parents and their offspring in the previous **two** generations.

(4)

(h) Explain what is meant by the term **human genome map** (paragraph 37).

(2)

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(i) Suggest how the 'p53 tumor suppressor gene' (paragraph 43) could stop a potential tumour cell forming.

(2)

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(j) Using paragraph 46, suggest what the 'specific DNA sequence from a blood cell' coded for.

(2)

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(k) A human telomere (paragraph 60) contains 10 000 nucleotides. Using information from paragraph 58, state the number of telomere nucleotides lost per cell division.

(1)

Answer ..... nucleotides

**(Total for question = 30 marks)**

Q18.

The scientific article you have studied is adapted from the book called The Immortal Life of Henrietta Lacks by Rebecca Skloot, published by Pan Books in 2011.

(a) MPF triggering (paragraph 6) starts the process of mitosis. Suggest **three** events that occur at the beginning of mitosis in a plant cell that may be triggered by MPF.

(3)

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(b) The genome makes sure that cells 'do their jobs, whether that's controlling your heartbeat or helping your brain understand the words on this page' (paragraph 10).

Suggest how cells sensitive to pH are involved in controlling heart rate.

(4)

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(c) 'Like guinea pigs and mice, Henrietta's cells have become the standard laboratory workhorse' (paragraph 16).

Suggest **three** reasons why Henrietta's cells are used routinely in medical research.

(3)

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\*(d) 'By the end of 1951, the world was in the midst of the biggest polio epidemic in history' (paragraph 19). This was caused by poliovirus which can lead to paralysis (paragraph 20).

The virus infects motor neurones which can stop skeletal muscles from working.

Explain how the structure of the cell surface membrane of a motor neurone is related to the conduction of a nerve impulse along its axon.

(6)

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(e) Poliovirus, like Human Immunodeficiency Virus, is a retrovirus. Poliovirus was able to infect HeLa cells (paragraph 25).

Give **three** differences between the structure of the genetic material in poliovirus and the genetic material in HeLa cells.

(3)

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(f) Scientists had studied genes by breeding animals 'then breeding their offspring to see how genetic traits are passed from one generation to the next' (paragraph 33).

When this was done using a brown mouse and a white mouse, it was found that in the F2 generation (second generation of offspring), 75% of the mice were brown.

In the space below, draw genetic diagrams to describe and explain the genotypes of the parents and their offspring in the previous **two** generations.

(4)

(g) Monoclonal antibodies are produced by hybrid cells. These cells are made by fusing a lymphocyte with a cancer cell, such as HeLa (paragraph 37).

Suggest why cancer cells are used to form these hybrid cells.

(2)

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(h) Suggest what is meant by the term **genetic engineering** (paragraph 47).

(2)

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(i) Place a cross ☒ in the box that shows the number of cells present if one cell divided 50 times by mitosis (paragraph 58).

(1)

- ☒ **A**  $2^5$
- ☐ **B**  $50^2$
- ☐ **C**  $5^{20}$
- ☐ **D**  $2^{50}$

(j) Scientists knew that 'there was a string of DNA at the end of each chromosome called a

*telomere*' (paragraph 60) and they also knew that 'human cancer cells contain an enzyme called *telomerase*' (paragraph 61).

State **four** chemical elements found in both telomeres and telomerase.

(2)

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**(Total for question = 30 marks)**

Q19.

The muscles of the earthworm (*Lumbricus terrestris*) contract when it is touched. This is known as the withdrawal response.

Which of the following terms describes a change in response as a result of repeated stimulation?

(1)

☐ **A** co-ordination

☐ **B** habituation

☐ **C** inhibition

☐ **D** reduction

**(Total for question = 1 mark)**

Q20.

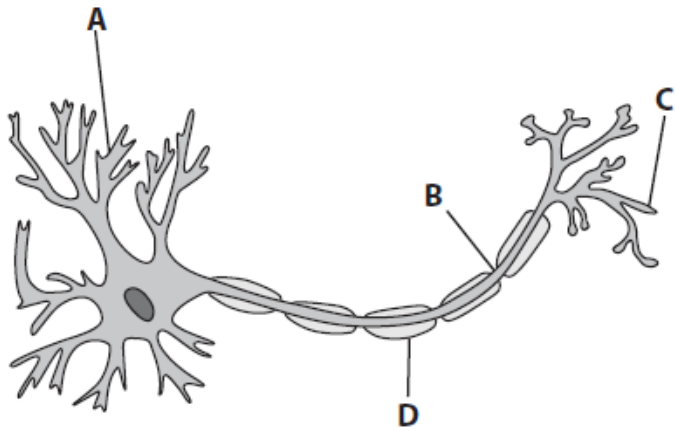
Voltage-gated  $K^+$  and  $Na^+$  channels are involved in the transmission of impulses in sensory and motor neurones.

(i) The table below identifies two stages in the transmission of an impulse in a sensory neurone.

Place a tick (✓) in each box that correctly identifies whether the channels are open or closed during these two stages.

| Stage          | Voltage-gated K <sup>+</sup> channels open | Voltage-gated K <sup>+</sup> channels closed | Voltage-gated Na <sup>+</sup> channels closed |
|----------------|--------------------------------------------|----------------------------------------------|-----------------------------------------------|
| Depolarisation |                                            |                                              |                                               |
| Repolarisation |                                            |                                              |                                               |

(ii) The diagram below shows a myelinated motor neurone.



Place a cross in the box ☒ that labels the site where neurotransmitters bind and initiate depolarisation.

- ☐ A
- ☐ B
- ☒ C
- ☐ D

Q21.

The scientific article you have studied is adapted from articles in *Nature* and *Scientific American*.

Use the information from the article and your own knowledge to answer the question.

\* Suggest how researchers had genetically modified the pathogen to 'provoke an effective immune response' (paragraph 12).

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Q22.

An investigation was carried out to study the effect of light on the mammalian retina.

Part of the retina of a young rat was removed and kept in the dark for two hours. This allowed the pigment in the rod cells to recover from bleaching caused by exposure to light.

Suggest **two** reasons why some people might have objections to the use of rats in this investigation.

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Q23.

The scientific article you have studied is adapted from articles in *Nature* and *Scientific American*.

Use the information from the article and your own knowledge to answer the question.

Octopamine is a neurotransmitter (paragraph 24). Libersat and his team believe that wasp venom probably blocks octopamine receptors in the central nervous system of the cockroach.

Suggest **two** ways that the 'compound that reactivates octopamine receptors' (paragraph 25) could work.

(2)

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Q24.

**Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.**

The retina of the human eye contains rod cells.  
These cells detect light energy as photons.

The light energy is converted to a nerve impulse that is interpreted by the brain.

(i) The transmission of an impulse between a neurone in the optic nerve and a cell in the brain involves ions and neurotransmitter molecules.

Describe how these ions and neurotransmitter molecules are involved in the transmission of an impulse.

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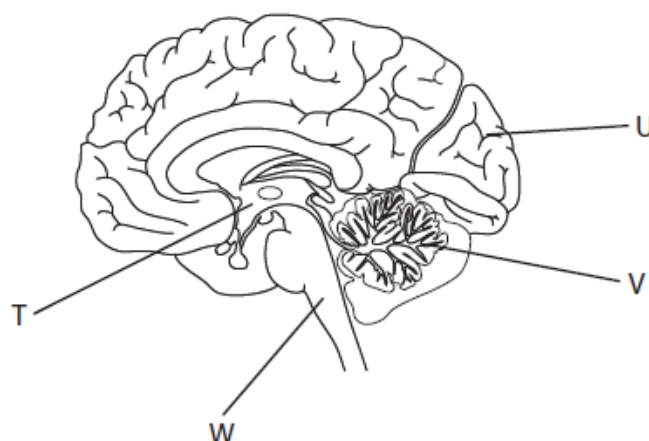
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(ii) The diagram shows a human brain.



Which label on the diagram identifies the area of the brain where an image is interpreted?

(1)

☐ **A** T

☐ **B** U

☐ C V

☐ D W

(Total for question = 5 marks)

Q25.

Habituation is a learning response observed in many types of animal.

The 'light-off jump' assay can be used to study habituation in fruit flies.

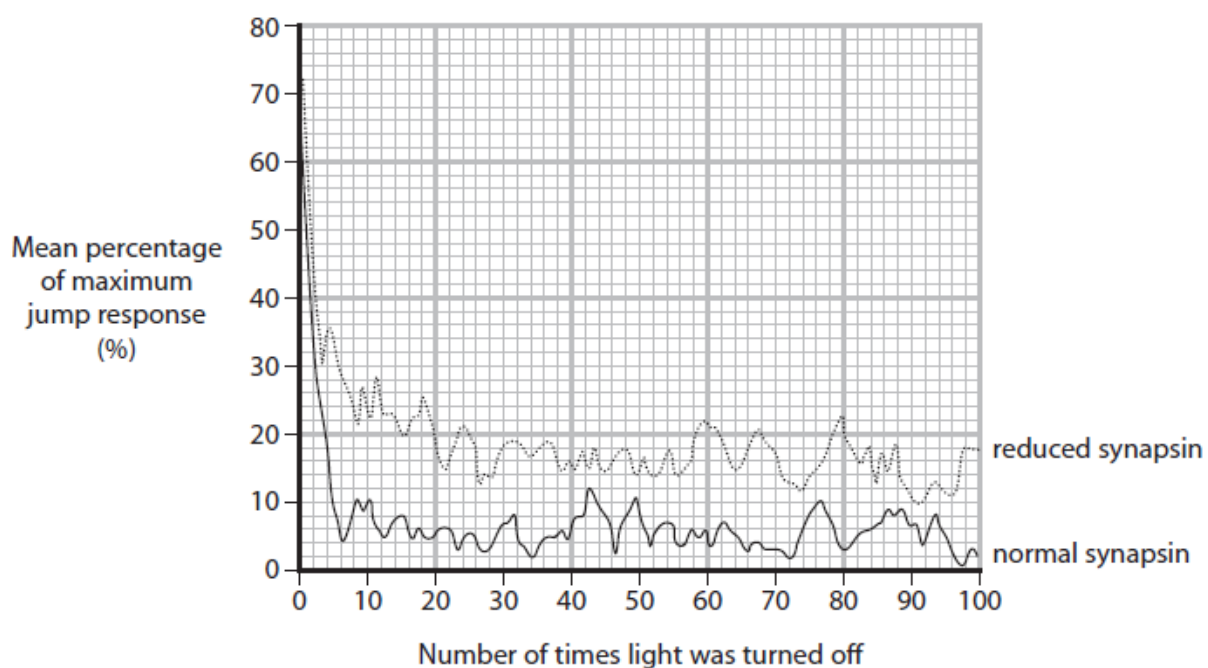
When the light is turned off the flies jump into the air and attempt to fly away.

The strength of this response can be measured by recording the noise made by the flies.

In one experiment, fruit flies with reduced expression of a protein called synapsin were compared with a control group.

Synapsin is a protein that inhibits the binding of presynaptic vesicles to the cell membrane.

The results of this experiment are shown in the graph.



(i) State two variables associated with the light-off stimulus that need to be controlled in this experiment.

(2)

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(ii) Determine the effect of reduced synapsin on the habituation of fruit flies in this experiment.

(3)

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(iii) Explain how reduced expression of synapsin could produce these results.

(3)

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**(Total for question = 8 marks)**

## Mark Scheme

Q1.

| Question Number                                               | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Mark                                |                                       |  |  |         |       |       |                                          |                          |                                     |                            |                                 |                          |                          |                                       |                                                               |                          |                          |                                       |                                    |                                       |                          |                          |     |
|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------------------------|--|--|---------|-------|-------|------------------------------------------|--------------------------|-------------------------------------|----------------------------|---------------------------------|--------------------------|--------------------------|---------------------------------------|---------------------------------------------------------------|--------------------------|--------------------------|---------------------------------------|------------------------------------|---------------------------------------|--------------------------|--------------------------|-----|
| (a)                                                           | <table><tr><th rowspan="2">Feature</th><th colspan="3">Type of neurone</th></tr><tr><th>Sensory</th><th>Relay</th><th>Motor</th></tr><tr><td>Found only in the central nervous system</td><td><input type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input type="checkbox"/> ;</td></tr><tr><td>Cell terminates at the effector</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input checked="" type="checkbox"/> ;</td></tr><tr><td>Pre-synaptic membrane not found in the central nervous system</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input checked="" type="checkbox"/> ;</td></tr><tr><td>Impulse stimulated by the receptor</td><td><input checked="" type="checkbox"/> ;</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr></table> | Feature                             | Type of neurone                       |  |  | Sensory | Relay | Motor | Found only in the central nervous system | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> ; | Cell terminates at the effector | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> ; | Pre-synaptic membrane not found in the central nervous system | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> ; | Impulse stimulated by the receptor | <input checked="" type="checkbox"/> ; | <input type="checkbox"/> | <input type="checkbox"/> | (4) |
| Feature                                                       | Type of neurone                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                     |                                       |  |  |         |       |       |                                          |                          |                                     |                            |                                 |                          |                          |                                       |                                                               |                          |                          |                                       |                                    |                                       |                          |                          |     |
|                                                               | Sensory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Relay                               | Motor                                 |  |  |         |       |       |                                          |                          |                                     |                            |                                 |                          |                          |                                       |                                                               |                          |                          |                                       |                                    |                                       |                          |                          |     |
| Found only in the central nervous system                      | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <input checked="" type="checkbox"/> | <input type="checkbox"/> ;            |  |  |         |       |       |                                          |                          |                                     |                            |                                 |                          |                          |                                       |                                                               |                          |                          |                                       |                                    |                                       |                          |                          |     |
| Cell terminates at the effector                               | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <input type="checkbox"/>            | <input checked="" type="checkbox"/> ; |  |  |         |       |       |                                          |                          |                                     |                            |                                 |                          |                          |                                       |                                                               |                          |                          |                                       |                                    |                                       |                          |                          |     |
| Pre-synaptic membrane not found in the central nervous system | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <input type="checkbox"/>            | <input checked="" type="checkbox"/> ; |  |  |         |       |       |                                          |                          |                                     |                            |                                 |                          |                          |                                       |                                                               |                          |                          |                                       |                                    |                                       |                          |                          |     |
| Impulse stimulated by the receptor                            | <input checked="" type="checkbox"/> ;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <input type="checkbox"/>            | <input type="checkbox"/>              |  |  |         |       |       |                                          |                          |                                     |                            |                                 |                          |                          |                                       |                                                               |                          |                          |                                       |                                    |                                       |                          |                          |     |

| Question Number | Answer            | Additional guidance | Mark |
|-----------------|-------------------|---------------------|------|
| (b)(i)          | hydrolysis / eq ; |                     | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                      | Additional guidance | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)(ii)         | <ol style="list-style-type: none"> <li>1. supplies energy to allow opsin and retinal to combine ;</li> <li>2. to (re)form rhodopsin ;</li> <li>3. use in the transport of ions e.g. to allow <math>\text{Na}^+</math> to be pumped out of cell ;</li> </ol> |                     | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional guidance | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)(iii)        | <ol style="list-style-type: none"> <li>reference to actin and myosin interacting ;</li> <li>ATP binds to myosin head causing {bond / cross-bridge / eq} between actin and myosin to break / eq ;</li> <li>ATP {breaks / hydrolyses} into ADP and <math>P_i</math> {releasing energy that is stored in myosin head / causing myosin head to reset / eq} ;</li> <li>myosin head binds to actin / {bond / cross-bridge forms} between actin and myosin / eq ;</li> <li><math>P_i</math> is released from myosin head / eq ;</li> <li>energy in myosin head causes it to move / eq ;</li> <li>idea that actin slides along ;</li> <li>ADP is released at this time / eq ;</li> <li>role of ATP in transport of calcium ions back into sarcoplasmic reticulum / eq ;</li> </ol> |                     | (5)  |

Q2.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                              | Additional Guidance                                                                                                                                 | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• nicotine similar in shape to acetylcholine (1)</li> <li>• increases permeability of membrane to sodium ions / changes shape of { receptors / channel proteins } (1)</li> <li>• nicotine causes the depolarisation of the post-synaptic membrane (1)</li> <li>• depolarisation reaches threshold level (1)</li> </ul> | <p>ALLOW { sodium ion / Na<sup>+</sup> } channels open</p> <p>ALLOW sodium ions { diffuse / move down concentration gradient } into the neurone</p> | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                   | Additional Guidance                                                             | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|------|
| (ii)            | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• (calcium ions cause) vesicles (containing noradrenaline) to fuse with { cell (surface) membrane / presynaptic membrane } (1)</li> </ul> | ALLOW (calcium ions cause) vesicles to release noradrenaline through exocytosis | (1)  |

Q3.

| Question Number | Answer                                                                                                                                                                                                                                           | Additional Comments                         | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------|
| (a)             | <p>1. only (alpha) 1-4 glycosidic bonds in amylose / (alpha) 1-6 only found in amylopectin ;</p> <p>2. only amylopectin has side branches / only amylose is {coiled / eq} ;</p> <p>3. Amylopectin is a {larger / eq} molecule than amylose ;</p> | 1. <b>ACCEPT</b> 1-6 and 1-4 in amylopectin | (2)  |

| Question Number | Answer                                                                                                                                              | Additional Comments                                                                                                                    | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <p>1. Different individuals in the {colony / eq} take on specific {roles / jobs / eq} ;</p> <p>2. Example given e.g. queen produces offspring ;</p> | <p>1. <b>Accept</b> division of labour</p> <p>2. <b>Accept</b> dominance by queen, {few of the males / kings} involved in breeding</p> | (2)  |

| Question Number | Answer                                                                | Additional Comments                                       | Mark |
|-----------------|-----------------------------------------------------------------------|-----------------------------------------------------------|------|
| (c) (i)         | Idea that body temperature of animal mimics the ambient temperature ; | <b>Accept</b> body temp follows environmental temperature | (1)  |



| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                         | Additional Comments | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (f)             | 1. idea of heart working less efficiently ;<br>2. idea of less oxygen absorbed at lungs / eq ;<br>3. less blood pumped to brain ;<br>4. concentration gradient (for oxygen) at brain reduced / eq ;<br>5. less oxygen in blood (in brain) diffuses into brain tissue / eq ;<br>6. idea of less oxygen in brain tissue due to continual (aerobic) respiration ; |                     | (3)  |

| Question Number | Answer                                                                                                                                                                                                                       | Additional Comments | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (g)             | gonadotrophin-releasing (hormone) stimulates gonadotrophin release /<br>gonadotrophin stimulates ovulation /<br>testosterone stimulates {sperm production / (male) secondary sexual characteristics / other named example} ; |                     | (1)  |

| Question Number | Answer                                                                                                     | Additional Comments                                                                   | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|------|
| (h)             | 1. Idea of effect on mitochondria ;<br>2. (therefore) reduced {energy / ATP / eq} for flagellum movement ; | 1. <b>Accept</b> less efficient / fewer / none<br>2. <b>Accept</b> tail for flagellum | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                    | Additional Comments       | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|------|
| (i)             | 1. idea that fat is an energy store ;<br>2. reduces dependence on external food source / eq ;<br>3. enables disperser to travel / eq ;<br>4. (metabolic) water is released (on oxidation) / eq ;<br>5. acts as a thermal insulator / eq ; | <b>Accept</b> energy-rich | (3)  |

| Question Number | Answer                                                                                                                                                          | Additional Comments                                                 | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|------|
| (j)             | 1. idea that unfamiliar males are likely to be genetically different ;<br>2. idea that this is outbreeding ;<br>3. idea that this increases genetic diversity ; | 3. <b>Accept</b> producing offspring that are genetically different | (2)  |

| Question Number | Answer                                                                                                             | Additional Comments                                                | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------|
| (k)             | the order of the {bases / genes and non-coding sequences / eq} in the DNA (of the naked mole rats) is found / eq ; | <b>Accept</b> exons and introns<br><b>Ignore</b> genes unqualified | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional Comments                   | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|------|
| (I)             | <p>Paired responses:</p> <ol style="list-style-type: none"> <li>1. reduced sensitivity to chemical pain / disconnection of 'pain nerves' ;</li> <li>2. Idea of pain relief e.g. dealing with post traumatic pain, post surgical pain, joint pain after a knee operation ;</li> <li>3. haemoglobin has higher affinity for oxygen ;</li> <li>4. Idea of dealing with reduced oxygen situations such as due to a heart attack or stroke ;</li> <li>5. Naked mole rat {incisors / eq } grow through skin (of lip) without damage ;</li> <li>6. Idea of better prosthesis e.g. new {coatings / permanent seal} at {skin / bone / metal} interface, soft tissue not damaged, avoid infection ;</li> <li>7. High protein stability / does not (easily) lose 3D shape ;</li> <li>8. (so) reduced effect of oxidative {damage / stress} / reduced effect of oxygen-containing free radicals / live healthily into old age ;</li> <li>9. Cell overcrowding early warning gene / ref. to two tiered contact inhibition / presence of gene p16 ;</li> <li>10. Idea of cancer prevention e.g. cancer resistance, future cancer therapy ;</li> <li>11. Naked mole rat neurones display immature {characteristics / physiological properties} / brain cells that cope with {low oxygen / hypoxia} ;</li> <li>12. To treat people with temporary loss of oxygen to brain e.g. heart attack, stroke, drowning / to prevent permanent brain damage ;</li> <li>13. High levels of oxytocin receptors in {brain / nucleus <u>accumbens</u>} ;</li> <li>14. Idea of links to autism ;</li> <li>15. Naked mole rats do not experience menopause ;</li> <li>16. Ref to osteoporosis {treatment / prevention} (without side effects) ;</li> <li>17. circadian rhythms / sleep patterns of naked mole rats ;</li> <li>18. Idea that may help with sleep disorders ;</li> </ol> | <b>9. Accept anticancer mechanism</b> |      |

Q4.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Additional guidance                                                                                                                                                    | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|                 | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• (give) {a precursor of dopamine / L-dopa} which can cross the blood brain barrier (1)</li> <li>• L-dopa is converted into dopamine (in the brain) (1)</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>• (give) a {drug that stops the breakdown of dopamine / MAO inhibitor} (1)</li> <li>• that can cross the blood brain barrier (1)</li> </ul> | <p>ALLOW</p> <ul style="list-style-type: none"> <li>• use of {electrode / deep brain stimulation}</li> <li>• to stimulate basal ganglia to produce dopamine</li> </ul> | <b>(2)</b> |

Q5.

| Question Number | Answer                        | Mark |
|-----------------|-------------------------------|------|
| (a)(i)          | B (between 12 and 15 hours) ; | (1)  |

| Question Number | Answer            | Mark |
|-----------------|-------------------|------|
| (a)(ii)         | D (phytochrome) ; | (1)  |

| Question Number | Answer                                                                                                                                                                                                           | Additional Guidance      | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------|
| (a)(iii)        | any two of the following standardised:<br><br>water / eq<br>mineral ion concentrations / eq<br>light intensity / eq<br>wavelength of light<br>CO <sub>2</sub> concentration,<br>temperature<br>pH<br>soil type ; | ACCEPT named mineral ion | (2)  |

| Question Number | Answer                                                       | Additional Guidance                                                    | Mark |
|-----------------|--------------------------------------------------------------|------------------------------------------------------------------------|------|
| (a)(iv)         | idea of using shorter time intervals e.g. 1 hour intervals ; | ACCEPT a description e.g. repeat with 12 hours of light, 13 hours, etc | (1)  |

| Question Number | Answer                                                                                                                                                | Additional Guidance | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)             | any one from:<br>temperature<br>water availability<br>the {wavelength / quality} of light<br>intensity of light<br>{edaphic / named edaphic} factor ; |                     | (1)  |

| Question Number | Answer                                                            | Additional Guidance | Mark |
|-----------------|-------------------------------------------------------------------|---------------------|------|
| (c)(i)          | outer segment / internal membranes / inner membranes / vesicles ; |                     | (1)  |

| Question Number              | Answer                        |                                      |                    | Mark |          |
|------------------------------|-------------------------------|--------------------------------------|--------------------|------|----------|
| (c)(ii)                      |                               |                                      |                    |      |          |
|                              | Description                   | Statement                            |                    |      |          |
|                              |                               | Opsin binds to the rod cell membrane | Rhodopsin bleaches |      | ATP used |
|                              | Rhodopsin responding to light | ✓                                    | ✓                  |      | ✗        |
|                              | Rhodopsin being reformed      | ✗                                    | ✗                  |      | ✓        |
| Any two correct for 1 mark ; |                               |                                      |                    | (3)  |          |

Q6.

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                   | Additional Guidance | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
|                 | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>positive phototropism (1)</li> <li>IAA diffuses away from light source (1)</li> <li>IAA accumulates in { cells / tissues } furthest from light (1)</li> <li>IAA stimulates cell elongation causing growth towards light (1)</li> </ul> |                     | (3)  |

Q7.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <p>The only correct answer is <b>D</b> – phytochrome change is <math>P_R</math> to <math>P_{FR}</math> and speed of change is rapid</p> <p><b>A</b> is incorrect because phytochrome does not change from <math>P_{FR}</math> to <math>P_R</math> in light and the process is rapid</p> <p><b>B</b> is incorrect because phytochrome does not change from <math>P_{FR}</math> to <math>P_R</math> in light</p> <p><b>C</b> is incorrect because the conversion is not slow</p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                   | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <p>The only correct answer is <b>B</b> – a photosensitive pigment</p> <p><b>A</b> is incorrect because phytochrome is not a form of opsin</p> <p><b>C</b> is incorrect because phytochrome is not an isomer of retinal</p> <p><b>D</b> is incorrect because not a type of cytochrome</p> | (1)  |

| Question Number | Answer                                                                                                                                              | Additional Guidance                                                                      | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------|
| (iii)           | <p>An answer that makes reference to one of the following:</p> <ul style="list-style-type: none"> <li>(seed) germination / flowering (1)</li> </ul> | <p>ALLOW chlorophyll synthesis / leaf development / stops growth e.g. falling leaves</p> | (1)  |

Q8.

| Question Number | Answer                        | Mark       |
|-----------------|-------------------------------|------------|
| <b>(a)</b>      | (leave it) in the dark / eq ; | <b>(1)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                 | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>(b)(i)</b>   | <p>1. mass higher in A ( compared with B) for both studies ;</p> <p>2. the difference is less in repeat study ;</p> <p>3. comparative manipulation of data e.g. 13g decrease for A to B for original and 5 g for repeat ;</p> <p>4. mass lower in repeats (of both A and B) / eq ;</p> | <b>(3)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                          | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>(b)(ii)</b>  | <ol style="list-style-type: none"> <li>1. { increase / eq} in stem length ;</li> <li>2. correct manipulation of the data e.g. by 23cm / 18.4% ;</li> <li>3. reference to {taller / faster growing / eq} seedling ;</li> <li>4. to receive {more light / higher red light / eq} / to maximize photosynthesis / eq ;</li> <li>5. idea of allows {active phytochrome / eq} to be made ;</li> </ol> | <b>(3)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                          | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>(b)(iii)</b> | <ol style="list-style-type: none"> <li>1. less red light {increases / eq} mean stem length / more far red light increases stem length / eq ;</li> <li>2. the (significant) difference in mean stem length is not due to {chance / eq} / eq ;</li> <li>3. the mean length for repeat was close to the original ;</li> <li>4. suggesting it is likely to be reliable ;</li> </ol> | <b>(3)</b> |

Q9.

| Question Number | Acceptable Answer                                                                                                                             | Additional Guidance | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(a)</b>      | <ul style="list-style-type: none"> <li><math>2.03 - 1.53 = 0.5 \div 2.03 \times 100</math> (1)</li> <li><math>= 24.63\%</math> (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional Guidance | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(b)</b>      | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>moving shadow and touch are perceived as presence of {danger / predator} (1)</li> <li>response to touch is greater than to shadow because touch perceived as {more dangerous/ closeness of predator} (1)</li> <li>response in tube is greater than response out of tube because tube provides physical surface to assist {contraction/ withdrawal} (1)</li> <li>worm has receptors and those for light generate less response than those for touch (1)</li> <li>when out of tube, a shadow stimulus affects all of a worm but a touch stimulus affects part of a worm (1)</li> </ul> |                     | <b>(3)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                | Additional Guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(c)(i)</b>   | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>prevents wasting energy (1)</li> <li>allows maximum feeding effort (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional Guidance                      | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------------|
| <b>(c)(ii)</b>  | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>there is less response because there is less depolarisation of the post-synaptic membrane (1)</li> <li>because there are fewer calcium ions entering the pre synaptic membrane so fewer vesicles fuse with the presynaptic cell membrane (1)</li> <li>so less neurotransmitter diffuses across the synaptic cleft (1)</li> <li>therefore less binding to the receptors on the post- synaptic membrane so fewer sodium channels open (1)</li> <li>resulting in no {action potential / impulse} in the post- synaptic neurone leading to no withdrawal response (1)</li> </ul> | Allow description of sodium ion movement | <b>(5)</b> |

Q10.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Additional guidance                                                                                                                                                                          | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|                 | <p>A description that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>• (isolate) the gene for the cytokine (from human DNA) (1)</li> <li>• use a bacterial plasmid (as a vector) (1)</li> <li>• cut the human DNA and the plasmid using the same restriction enzyme (1)</li> <li>• splice the gene and plasmid together using (DNA) ligase (1)</li> <li>• put the (modified) plasmids into bacterial cells (1)</li> </ul> | <p>e.g. use a restriction enzyme to cut the DNA and the plasmid</p> <p>ALLOW 'join' for 'splice'</p> <p>ALLOW produce lots of bacteria (with the plasmid / expressing the cytokine gene)</p> | <b>(4)</b> |

Q11.

| Question Number | Acceptable Answer                                 | Additional guidance             | Mark       |
|-----------------|---------------------------------------------------|---------------------------------|------------|
| <b>(a)(i)</b>   | <p>49 182 000 x 0.05 (1)</p> <p>2 459 100 (1)</p> | Correct answer gains full marks | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                      | Additional guidance | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(a)(ii)</b>  | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• can dilate bronchioles /airways (1)</li> <li>• therefore allowing more oxygen into lungs /alveoli (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                              | Additional guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(a)(iii)</b> | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• sympathetic neurotransmitters are released at the SAN (1)</li> <li>• therefore if beta-2 agonists are present the SAN will increase its rate of stimulation (1)</li> <li>• so impulses will spread faster and more often over the atria (1)</li> <li>• therefore the heart muscle will contract more often which increases the heart rate (1)</li> </ul> |                     | <b>(4)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                        | Additional guidance | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(b)</b>      | <p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>HGH binds to receptor in cell surface membrane (1)</li> <li>activation of messenger molecule in cytoplasm (1)</li> <li>reference to protein kinase cascade (1)</li> <li>transcription factor produced (1)</li> <li>gene for IGF-1 switched on (1)</li> </ul> |                     | <b>(4)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                              | Additional guidance | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(c)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>occur naturally / would have some present in body (1)</li> <li>therefore difficult to detect additional HGH (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                             | Additional guidance | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(d)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>no need for blood transfusion (1)</li> </ul> <p>plus any one from:</p> <ul style="list-style-type: none"> <li>therefore no risk of rejection / agglutination/ delay in {tissue/blood} typing (1)</li> <li>they supply the oxygen requirements for the body (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------|
| <b>(e)</b>      | <p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>reference to {sodium ion channels / voltage gated sodium ion channels} (1)</li> <li>binding blocks movement of sodium ions into neurone (1)</li> <li>membrane is not depolarised (1)</li> <li>action potential is not generated (1)</li> <li>no impulses conducted to brain (1)</li> </ul> | Accept more sophisticated answers that refer to the effect on calcium ion movement | <b>(4)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                               | Additional guidance | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(f)</b>      | <p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>• (they) increase the removal of {water/salts} from blood (1)</li> <li>• (removal of water) lowers blood volume and therefore pressure (1)</li> <li>• (removal of salt) lowers uptake of water into blood (by osmosis from tissue fluid) and therefore blood pressure (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                   | Additional guidance | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(g)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• normal ratio is 1:1 (1)</li> <li>• taking testosterone and epitestosterone in equal measures maintains this ratio (1)</li> <li>• therefore it is not possible to detect cheats (1)</li> </ul> |                     | <b>(3)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                       | Additional guidance                                 | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------|
| <b>(h)</b>      | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• drug E has been retained in the gas phase longer (1)</li> <li>• because it has {greater solubility / smaller mass} (1)</li> </ul> | Accept more sophisticated answers related to charge | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                  | Additional guidance | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(i)</b>      | <p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>• longitudinal monitoring / to be followed over time (1)</li> <li>• therefore can identify individual differences in naturally occurring drug concentrations (1)</li> <li>• therefore can see pattern or link to competition / injury / look for changes (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Acceptable Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(i)</b>      | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>the absolutist's view would be that they should never be used (1)</li> </ul> <p>plus any one from:</p> <ul style="list-style-type: none"> <li>because of the damage to the body by the side effects (1)</li> <li>athletes should compete using their innate {anatomical / physiological} abilities / fair competition should be promoted (1)</li> </ul> <p>and</p> <ul style="list-style-type: none"> <li>the rationalist's view would be that their use is acceptable if there is a justifiable outcome (1)</li> </ul> <p>Plus any one from:</p> <ul style="list-style-type: none"> <li>because it is a personal choice (1)</li> <li>because it could help to overcome the inequalities in {training / medical support} (1)</li> </ul> |                     | <b>(4)</b> |

Q12.

| Question Number | Acceptable Answer | Additional Guidance | Mark       |
|-----------------|-------------------|---------------------|------------|
|                 | C                 |                     | <b>(1)</b> |

Q13.

| Question Number | Answer                                                                                                       | Mark                |            |
|-----------------|--------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(a)(i)</b>   | B ;                                                                                                          | <b>(1)</b>          |            |
| Question Number | Answer                                                                                                       | Mark                |            |
| <b>(a)(ii)</b>  | D ;                                                                                                          | <b>(1)</b>          |            |
| Question Number | Answer                                                                                                       | Mark                |            |
| <b>(a)(iii)</b> | A ;                                                                                                          | <b>(1)</b>          |            |
| Question Number | Answer                                                                                                       | Mark                |            |
| <b>(a)(iv)</b>  | D ;                                                                                                          | <b>(1)</b>          |            |
| Question Number | Answer                                                                                                       | Mark                |            |
| <b>(a)(v)</b>   | A ;                                                                                                          | <b>(1)</b>          |            |
| Question Number | Answer                                                                                                       | Additional guidance | Mark       |
| <b>(b)</b>      | 1. Ideas of (muscles) work antagonistically ;<br>2. circular muscle relaxes ;<br>3. radial muscle contracts; | ACCEPT 2 stretched  | <b>(2)</b> |

Q14.

| Question Number | Answer                                                                                                                                                                                                                 | Additional guidance                                           | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|------------|
|                 | An answer that makes reference to the following: <ul style="list-style-type: none"> <li>• transfer of antibiotic-resistance gene to other microorganisms (1)</li> <li>• a reason associated with health (1)</li> </ul> | e.g. pathogenic bacteria developing resistance to antibiotics | <b>(2)</b> |

Q15.

| Question Number                       | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Mark                                |                                     |                                     |  |  |   |   |   |   |                              |                                     |                                     |                                     |                                     |                                       |                                     |                                     |                                     |                                     |                               |                                     |                                     |                                     |                                     |          |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--|--|---|---|---|---|------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|----------|
| (a)                                   | <table><tr><th rowspan="2">Description</th><th colspan="4">Area of the rod cell</th></tr><tr><th>A</th><th>B</th><th>C</th><th>D</th></tr><tr><td>Nearest the pupil of the eye</td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td></tr><tr><td>Containing the photosensitive pigment</td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td></tr><tr><td>Has the pre-synaptic membrane</td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input checked="" type="checkbox"/></td></tr></table> | Description                         | Area of the rod cell                |                                     |  |  | A | B | C | D | Nearest the pupil of the eye | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | Containing the photosensitive pigment | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | Has the pre-synaptic membrane | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | Comp (3) |
| Description                           | Area of the rod cell                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                     |                                     |                                     |  |  |   |   |   |   |                              |                                     |                                     |                                     |                                     |                                       |                                     |                                     |                                     |                                     |                               |                                     |                                     |                                     |                                     |          |
|                                       | A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | B                                   | C                                   | D                                   |  |  |   |   |   |   |                              |                                     |                                     |                                     |                                     |                                       |                                     |                                     |                                     |                                     |                               |                                     |                                     |                                     |                                     |          |
| Nearest the pupil of the eye          | <input checked="" type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |  |   |   |   |   |                              |                                     |                                     |                                     |                                     |                                       |                                     |                                     |                                     |                                     |                               |                                     |                                     |                                     |                                     |          |
| Containing the photosensitive pigment | <input checked="" type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |  |   |   |   |   |                              |                                     |                                     |                                     |                                     |                                       |                                     |                                     |                                     |                                     |                               |                                     |                                     |                                     |                                     |          |
| Has the pre-synaptic membrane         | <input checked="" type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  |  |   |   |   |   |                              |                                     |                                     |                                     |                                     |                                       |                                     |                                     |                                     |                                     |                               |                                     |                                     |                                     |                                     |          |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional Comments                                                                                                                                                                                               | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b) (i)         | 1. reference to light intensity required / eq ;<br>2. light {absorbed / eq} by rhodopsin / eq ;<br>3. rhodopsin changes shape / eq ;<br>4. rhodopsin is converted to retinal AND <u>opsin</u> / eq ;<br>5. <u>opsin</u> binds with cell surface membrane / eq ;<br>6. idea of fewer {sodium ions /Na <sup>+</sup> } enter rod cell ;<br>7. idea of sodium ions pumped out of rod cell ;<br>8. hyperpolarisation occurs (leading to change in voltage) / eq ; | 2. <b>Ignore</b> hits<br>3. <b>Accept</b> <u>Cis</u> to Trans retinal<br>4. <b>Ignore</b> bleaching<br>6. <b>Accept</b> decreases permeability (of membrane) to {sodium ions /Na <sup>+</sup> }, channels close ; | (4)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                     | Additional Comments                                                                               | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|------|
| (b) (ii)        | 1. idea of not enough {rhodopsin is converted / <u>opsin</u> binds to membrane} ;<br>2. (so) change in voltage is insufficient / eq ;<br>3. idea of { neurotransmitter / glutamate } still released (from rod cell) ;<br>4. idea that depolarisation in bipolar neurone insufficient ;<br>5. idea of bipolar neurone already depolarised ; | 4. <b>Accept</b> for depolarisation- { threshold level, generator potential , EPSP } not achieved | (2)  |

Q16.

| Question Number | Answer       | Mark |
|-----------------|--------------|------|
| (i)             | A ; cerebrum | (1)  |

| Question Number | Answer           | Mark |
|-----------------|------------------|------|
| (ii)            | C ; hypothalamus | (1)  |

Q17.

| Question Number | Answer                                                                                                                                                                                                                      | Additional Guidance                                                                                                                                     | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <ol style="list-style-type: none"> <li>1. involves prophase, metaphase, anaphase and telophase ;</li> <li>2. idea that produces two nuclei ;</li> <li>3. idea that these are genetically identical to original ;</li> </ol> | <ol style="list-style-type: none"> <li>1. NOT if cytokinesis or interphase included as part of mitosis</li> <li>2. ACCEPT produces two cells</li> </ol> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                            | Additional Guidance | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)             | <ol style="list-style-type: none"> <li>1. (SAN) is myogenic / description given ;</li> <li>2. electrical activity from SAN causes atria to contract / eq ;</li> <li>3. idea that activity of SAN can be changed by nerve impulses e.g. controlled by medulla ;</li> <li>4. credit detail of nervous control e.g. more impulses from accelerator increases heart rate ;</li> </ol> |                     | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                         | Additional Guidance | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (c)             | <ol style="list-style-type: none"> <li>1. idea that lactase gene {activated / transcribed} ;</li> <li>2. (synthesis of) lactase / eq ;</li> <li>3. hydrolysis of lactose / glycosidic bonds broken ;</li> <li>4. to produce glucose AND galactose ;</li> </ol> |                     | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                       | Additional Guidance                                                                                                                                         | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (d)             | <ol style="list-style-type: none"> <li>1. idea that a better model than guinea pigs or mice ;</li> <li>2. idea of animal rights ;</li> <li>3. easy to culture / eq ;</li> <li>4. (HeLa cells) susceptible to disease / HPV / eq ;</li> </ol> | <ol style="list-style-type: none"> <li>1. ACCEPT reference to only HeLa {cells / DNA} are human</li> <li>3. ACCEPT cheaper (as continual supply)</li> </ol> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                  | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| *(e)            | <p>(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence)</p> <ol style="list-style-type: none"> <li>1. idea that {motor neurone / cell body / nucleus} is destroyed ;</li> <li>2. depolarisation does not occur in the neurone / (insufficient so) no action potential set up in the neurone ;</li> <li>3. detail of (depolarisation / action potential) not occurring in neurone e.g. idea <math>\text{Na}^+</math> does not diffuse into neurone ;</li> <li>4. {neurotransmitter / named neurotransmitter} not {released / produced / eq} at junction with muscle / eq ;</li> <li>5. detail of lack of neurotransmitter release e.g. vesicles (containing neurotransmitter) do not {move / fuse} with {presynaptic membrane /</li> </ol> | <p>QWC emphasis is clarity of expression</p> <ol style="list-style-type: none"> <li>1. ACCEPT idea of damage to myelin sheath / Schwann cells</li> <li>3. ACCEPT <math>\text{Na}^+</math> / cation channels {non-functional / eq}</li> <li>4. ACCEPT {neurotransmitter / named neurotransmitter} not {released / produced / eq} at {motor neurone presynaptic membrane / motor end plate}</li> </ol> |      |

|  |                                                                                                                                                                                                                                                                                                     |                                                                           |            |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|------------|
|  | <p>eq} / eq ;</p> <p>6. <math>\text{Ca}^{2+}</math> not released into muscle cytoplasm ;</p> <p>7. <math>\text{Ca}^{2+}</math> not released from sarcoplasmic reticulum ;</p> <p>8. no <math>\text{Ca}^{2+}</math> to {activate / eq} troponin ;</p> <p>9. idea that muscle does not contract ;</p> | <p>6. ACCEPT <math>\text{Ca}^{2+}</math> not released into sarcoplasm</p> | <b>(6)</b> |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|------------|

| Question Number | Answer                                                                                                                                                                                     | Additional Guidance                                                                                  | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------------|
| <b>(f)</b>      | <p>1. contains bases / eq ;</p> <p>2. contain phosphate (groups) ;</p> <p>3. have a pentose sugar ;</p> <p>4. reference to phosphodiester bonds ;</p> <p>5. idea of discrete strands ;</p> | <p>1. ACCEPT both have (4) bases / nucleotides</p> <p>3. ACCEPT 5C sugar</p> <p>5. ACCEPT linear</p> | <b>(3)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                 | Additional Guidance                     | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|------------|
| <b>(g)</b>      | <p>1. smooth shown as dominant / wrinkled shown as recessive e.g. use of upper and lower case ;</p> <p><b>Parental generation:</b></p> <p>2. both types shown as homozygous ;</p> <p><b>F1:</b></p> <p>3. all shown as heterozygous ;</p> <p><b>F2:</b></p> <p>4. genetic diagram to show that 75% are smooth / 25% are wrinkled ;</p> | <p>4. Diagram should show genotypes</p> | <b>(4)</b> |

| Question Number | Answer                                                                                                                                                                                                          | Additional Guidance              | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------|
| (h)             | <ol style="list-style-type: none"> <li>all the {DNA / eq} found in {a human / the human species / eq} ;</li> <li>idea of genes {on different chromosomes / different positions on same chromosome} ;</li> </ol> | 1. ACCEPT population for species | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional Guidance                                                                                                                                                                                                      | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <ol style="list-style-type: none"> <li>product (of p53 gene) {stops / eq} development of tumour cells / eq</li> </ol> <p>OR</p> <ol style="list-style-type: none"> <li>product (of p53 gene) {stops / regulates} progression {of cell cycle / towards mitosis} ;</li> <li>acts as an inhibitor of {transcription / protein synthesis / eq} / eq ;</li> <li>idea that {DNA / eq} repair ;</li> <li>idea that leads to apoptosis ;</li> </ol> | <ol style="list-style-type: none"> <li>ACCEPT product stops tumour cells growing / dividing</li> <li>ACCEPT product keeps it in {interphase / named mitotic stage} / product interferes with mitosis progress</li> </ol> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                | Additional Guidance          | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|------|
| (j)             | <ol style="list-style-type: none"> <li>protein / glycoprotein ;</li> <li>reference to this being CD4 ;</li> <li>found on cell (surface) membrane / eq ;</li> <li>that acts as a {receptor / named receptor} for HIV / eq ;</li> </ol> | 4. ACCEPT receptor for gp120 | (2)  |

| Question Number | Answer              | Mark |
|-----------------|---------------------|------|
| (k)             | 200 (nucleotides) ; | (1)  |

Q18.

| Question Number | Answer                                                                                                                                                                                                                  | Additional guidance | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (a)             | <ol style="list-style-type: none"> <li>1. chromosomes / eq (continue to) condense ;</li> <li>2. nuclear envelope breaks down ;</li> <li>3. spindles (fibres) form ;</li> <li>4. nucleolus breaks down / eq ;</li> </ol> |                     | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                 | Additional guidance | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)             | <ol style="list-style-type: none"> <li>1. (pH sensitive cells) detect a change in blood pH / eq ;</li> <li>2. these are in the {carotid body / carotid artery / aortic body / aorta / medulla} ;</li> <li>3. alter impulse rate to brain / eq ;</li> <li>4. reference to cardiac centre ;</li> <li>5. in medulla ;</li> <li>6. change impulse rate of SAN ;</li> </ol> |                     | (4)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                    | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | <ol style="list-style-type: none"> <li>1. idea that reproduce rapidly / {robust / hardy} so many can be formed rapidly ;</li> <li>2. easy to culture / eq ;</li> <li>3. (HeLa cells) susceptible to disease / HPV / eq ;</li> <li>4. genome known / eq ;</li> <li>5. idea that they have no Hayflick limit ;</li> </ol> | <ol style="list-style-type: none"> <li>2. ACCEPT cheaper (as continual supply)</li> <li>3. ACCEPT other named disease</li> <li>4 ACCEPT reference to (HeLa) cells are human</li> </ol> | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional guidance                                                              | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------------|
| *(d)            | <p>(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence)</p> <ol style="list-style-type: none"> <li>1. phospholipid bilayer ;</li> <li>2. idea of its hydrophobic properties inhibit movement of ions across membrane ;</li> <li>3. Na<sup>+</sup> gated channel present ;</li> <li>4. to allow Na<sup>+</sup> to enter during depolarisation / to open when local currents occur ;</li> <li>5. K<sup>+</sup> channels ;</li> <li>6. to allow K<sup>+</sup> to diffuse ;</li> <li>7. sodium–potassium pump / eq ;</li> <li>8. to {export Na<sup>+</sup>/ import K<sup>+</sup>} ;</li> <li>9. role of pump in neurone membrane ;</li> <li>10.idea that only parts of the membrane may be involved e.g. nodes of Ranvier ;</li> </ol> | <p>QWC emphasis is logical sequence</p> <p>10. ACCEPT salutatory condition ;</p> | <b>(6)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                   | Additional guidance | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (e)             | <ol style="list-style-type: none"> <li>idea of double stranded only in HeLa ;</li> <li>idea of too many H bonds in HeLa / {complementary bases / base pairs} ;</li> <li>thymine only found in HeLa genetic material / uracil only in poliovirus ;</li> <li>sugar present in HeLa is deoxyribose / ribose in poliovirus / eq ;</li> </ol> |                     | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                       | Additional guidance | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (f)             | <ol style="list-style-type: none"> <li>brown shown as dominant / white shown as recessive e.g. use of upper and lower case;</li> </ol> <p><b>Parental generation:</b></p> <ol style="list-style-type: none"> <li>both types shown as homozygous ;</li> </ol> <p><b>F1:</b></p> <ol style="list-style-type: none"> <li>all shown as heterozygous ;</li> </ol> |                     |      |

|  |                                                                               |                                  |            |
|--|-------------------------------------------------------------------------------|----------------------------------|------------|
|  | <b>F2:</b><br>4. genetic diagram to show that 75% are brown / 25% are white ; | 4. Diagram should show genotypes | <b>(4)</b> |
|--|-------------------------------------------------------------------------------|----------------------------------|------------|

| Question Number | Answer                                                                                                        | Additional guidance               | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------|-----------------------------------|------------|
| <b>(g)</b>      | 1. allow continual division (of hybrid) ;<br><br>2. idea of continual production of (monoclonal) antibodies ; | 1. ACCEPT division is rapid / eq; | <b>(2)</b> |

| Question Number | Answer                                                                                                                                                | Additional guidance | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>(h)</b>      | 1. modification of {genome / DNA / eq} ;<br><br>2. reference to the addition of {genetic material / eq} from another {organism / species / eq} / eq ; |                     | <b>(2)</b> |

| Question Number | Answer           | Mark       |
|-----------------|------------------|------------|
| <b>(i)</b>      | D ( $2^{50}$ ) ; | <b>(1)</b> |

| Question Number | Answer                                                               | Additional guidance        | Mark       |
|-----------------|----------------------------------------------------------------------|----------------------------|------------|
| <b>(j)</b>      | Any two for 1 mark:<br><br>Carbon / hydrogen / oxygen / nitrogen ; ; | ACCEPT as chemical symbols | <b>(2)</b> |

Q19.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                       | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>The only correct answer is B – habituation</p> <p><i>A is not correct because co- ordination is a general term not restricted to changes given</i></p> <p><i>C is not correct because inhibition does not describe a change in response</i></p> <p><i>D is not correct because it is not a term with meaning in the context of change of response</i></p> | (1)  |

Q20.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                      | Additional Guidance                         | Mark                                         |                                             |                                              |                |  |   |  |                |   |  |   |                                                                      |     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------------------------------------------|---------------------------------------------|----------------------------------------------|----------------|--|---|--|----------------|---|--|---|----------------------------------------------------------------------|-----|
| (i)             | <table border="1"> <thead> <tr> <th>Stage</th><th>Voltage-gated K<sup>+</sup> channel open</th><th>Voltage-gated K<sup>+</sup> channel closed</th><th>Voltage-gated Na<sup>+</sup> channel closed</th></tr> </thead> <tbody> <tr> <td>Depolarisation</td><td></td><td>✓</td><td></td></tr> <tr> <td>Repolarisation</td><td>✓</td><td></td><td>✓</td></tr> </tbody> </table> | Stage                                       | Voltage-gated K <sup>+</sup> channel open    | Voltage-gated K <sup>+</sup> channel closed | Voltage-gated Na <sup>+</sup> channel closed | Depolarisation |  | ✓ |  | Repolarisation | ✓ |  | ✓ | <p>3 columns correct = 2 marks</p> <p>2 columns correct = 1 mark</p> | (2) |
| Stage           | Voltage-gated K <sup>+</sup> channel open                                                                                                                                                                                                                                                                                                                                   | Voltage-gated K <sup>+</sup> channel closed | Voltage-gated Na <sup>+</sup> channel closed |                                             |                                              |                |  |   |  |                |   |  |   |                                                                      |     |
| Depolarisation  |                                                                                                                                                                                                                                                                                                                                                                             | ✓                                           |                                              |                                             |                                              |                |  |   |  |                |   |  |   |                                                                      |     |
| Repolarisation  | ✓                                                                                                                                                                                                                                                                                                                                                                           |                                             | ✓                                            |                                             |                                              |                |  |   |  |                |   |  |   |                                                                      |     |

| Question Number | Answer | Mark |
|-----------------|--------|------|
| (ii)            | A ;    | (1)  |

Q21.

| Question Number | Answer                                                                                                                                                                                                                                                                        | Additional Guidance                        | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------|
| *               | <p><b>(QWC – Spelling of technical terms must be correct and the answer must be organised in a logical sequence)</b></p> <p>1. identify a gene that {provokes an effective immune response / codes for {antigen / eq} / inhibits <i>T. gondii</i> entering {brain/muscle}</p> | QWC with emphasis on clarity of expression |      |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                   |     |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----|
|  | <p>cells} ;</p> <p>2. gene removed using a {restriction enzyme / endonuclease} ;</p> <p>3. {same / this / eq} restriction enzyme used to open {<i>T. gondii</i> genome / eq} / eq ;</p> <p>4. sticky ends {formed / eq} ;</p> <p>5. ligase used to bind gene / eq ;</p> <p>6. by forming phosphodiester bonds / eq ;</p> <p>7. idea of method of introducing gene into pathogen ;</p> <p>8. idea that gene needs to be expressed e.g. protein synthesised ;</p> <p>9. idea of this protein in provoking an immune response ;</p> <p>10. detail of immune response ;</p> | <p>3. <b>NOT</b> plasmid cut open</p> <p>7. <b>IGNORE</b> plasmid</p> <p>8. <b>ACCEPT</b> synthesises antigen</p> | (6) |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----|

| Question Number | Answer                                                                                                                                                                                                                                                                      | Additional Guidance                                                                                                                                        | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | 1. idea of rats have rights ;<br><br>2. rats made {blind/ eq } ;<br><br>3. 15 samples may not be sufficient for a reliable investigation / eq ;<br><br>4. idea that rat retina may not behave like human retina (so investigation has no (potential) medical application) ; | 1. <b>ACCEPT</b> lack of consent given<br><br>2. <b>ACCEPT</b> harmed, causes pain, requires killing rats<br><br>4. <b>ACCEPT</b> tissue culture available | (2)  |

Q23.

| Question Number | Answer                                                                                                                                                                                                                                                                                                      | Additional Guidance | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
|                 | 1. idea that it binds to wasp venom so it {is removed from / can no longer bind to} receptor ;<br><br>2. idea that breaks down wasp venom so it leaves receptor ;<br><br>3. idea that wasp venom binds more readily to it than to the receptor ;<br><br>4. idea of the nature of the compound e.g. enzyme ; |                     | (2)  |

Q24.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Additional guidance                                                                                                                                                                                                           | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> <li>calcium ions enter presynaptic neurone so vesicles with neurotransmitter can {move towards / fuse with presynaptic membrane} (1)</li> <li>neurotransmitter molecules diffuse across the synapse (1)</li> <li>neurotransmitter to bind with receptors on postsynaptic membrane (on the brain cell) (1)</li> <li>sodium ions diffuse into {brain cell / post-synaptic cell} leading to {a depolarisation / an action potential} (1)</li> </ul> | <p>ALLOW calcium ions enter presynaptic neurone leading to exocytosis of neurotransmitter from vesicles</p> <p>ALLOW named neurotransmitter such as acetylcholine, dopamine, noradrenaline</p> <p>ALLOW enter for diffuse</p> | (4)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                       | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <p><b>The only correct answer is B - U - This is the site in the brain where the image is interpreted</b></p> <p><i>A is not correct because T is not the site in the brain where the image is interpreted</i></p> <p><i>C is not correct because V is not the site in the brain where the image is interpreted</i></p> <p><i>D is not correct because W is not the site in the brain where the image is interpreted</i></p> | (1)  |

Q25.

| Question number | Answer                                                                                                                                                                                                                                     | Additional guidance                                         | Mark                     |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------|
| (i)             | <p>An answer that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>frequency of light-off pulses (1)</li> <li>duration of light-off pulse (1)</li> <li>{wavelength / intensity} of light (1)</li> </ul> | <p>ALLOW interval between {pulses / turning lights off}</p> | <p>Expert</p> <p>(2)</p> |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                                                                                                                                                                                                                                                                 | Mark          |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| (ii)            | <p>An answer that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• (with reduced synapsin) habituation is not as complete / there was a greater percentage of maximum jump response (1)</li> <li>• (with reduced synapsin) habituation takes place more slowly / jump-response decreases more slowly (1)</li> <li>• appropriate {manipulation / comparative use of data} (1)</li> </ul> | <p>ALLOW converse for normal synapsin</p> <p>ALLOW higher jump-response / jumped more</p> <p>e.g. jump response decreases by (14-4) 10% more with normal synapsin / takes (305) 25 more light-off stimuli to get maximum response for reduced synapsin after 100 light stimuli 16% higher with reduced synapsin</p> | Expert<br>(3) |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Additional guidance                                                                                     | Mark          |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|---------------|
| (iii)           | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• (reduced synapsin) increases the number of vesicles fusing with the presynaptic membrane (1)</li> <li>• (resulting in more) {exocytosis / release} of neurotransmitter (into the synapse) (1)</li> <li>• therefore, (more) action potentials generated in post synaptic membrane (1)</li> <li>• therefore the flies (continue to) respond to the light-off stimulus (1)</li> </ul> | <p>ALLOW vesicles can continue to fuse</p> <p>ALLOW (more) depolarisation of post synaptic membrane</p> | Expert<br>(3) |

Q1.

The scientific article you have studied is from *Scientific American*.

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

Sight is a sense that develops during a critical period, 'providing a basis on which the brain can compute the activity needed for self-preservation.' (paragraph 22).

Describe what is meant by a critical period.

(2)

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**(Total for question = 2 marks)**

Q2.

Nicotine is a drug found in the smoke of cigarettes.

The effect of inhaling nicotine on the circulatory system of rats was investigated.

In this investigation, three variables were considered:

- the concentration of nicotine in blood plasma
- the diameter of the lumen of one artery
- blood pressure

Two groups of rats were treated as shown in the table.

| Group | Number of rats in group | Nicotine dose / mg |
|-------|-------------------------|--------------------|
| A     | 6                       | 1.0                |
| B     | 6                       | 0.1                |

(i) The concentration of nicotine in the blood plasma of the group A rats was recorded at different times and

the means calculated.

The means are shown in the table along with the range of data for each mean.

| Time of sampling / minutes       | Mean concentration of nicotine in blood plasma / $\text{ng cm}^{-3}$ |
|----------------------------------|----------------------------------------------------------------------|
| 0 (immediately after inhalation) | $35.0 \pm 9.3$                                                       |
| 30 (after inhalation)            | $24.1 \pm 5.6$                                                       |

Determine the maximum rate of decrease in the concentration of nicotine in the blood plasma per minute after being given the nicotine.

(2)

Answer .....  $\text{ng cm}^{-3} \text{ min}^{-1}$

(ii) The diameter of the lumen of one artery, in each of the 12 rats, was measured

when the rats were resting. The blood pressure of each rat was also measured and the mean blood pressure calculated.

The diameter of the lumen of the artery and the blood pressure of each rat were then recorded at intervals, for a total of 30 minutes. The rats inhaled nicotine for the first minute (0.0 to 1.0).

The table shows the results for the mean diameter of the lumen of the artery.

| Time / minutes | Mean diameter of lumen / $\mu\text{m}$ |                           |
|----------------|----------------------------------------|---------------------------|
|                | Group A (1.0 mg nicotine)              | Group B (0.1 mg nicotine) |
| 0.0            | 48                                     | 48                        |
| 0.5            | 44                                     | 44                        |
| 1.0            | 49                                     | 45                        |
| 2.0            | 52                                     | 48                        |
| 5.0            | 57                                     | 52                        |
| 10.0           | 55                                     | 48                        |
| 15.0           | 49                                     | 48                        |
| 30.0           | 49                                     | 48                        |

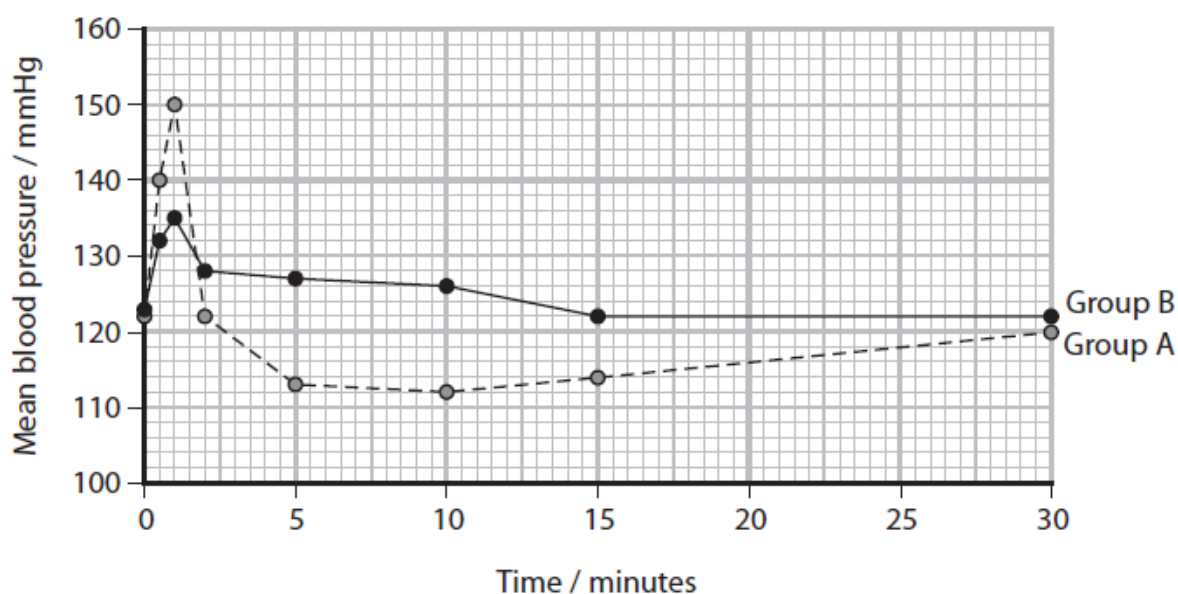
Determine the effect of nicotine concentration on the percentage change in lumen diameter in the first minute.

(2)

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\*(iii) The graph shows the results for the mean blood pressure for the two groups of rats. Nicotine was inhaled for the first minute.



It has been stated that:

'Nicotine gained from smoking cigarettes in humans causes an increase in blood pressure and a decrease in the lumen of arteries.'

Analyse all the data from this investigation using rats to evaluate the validity of this statement.

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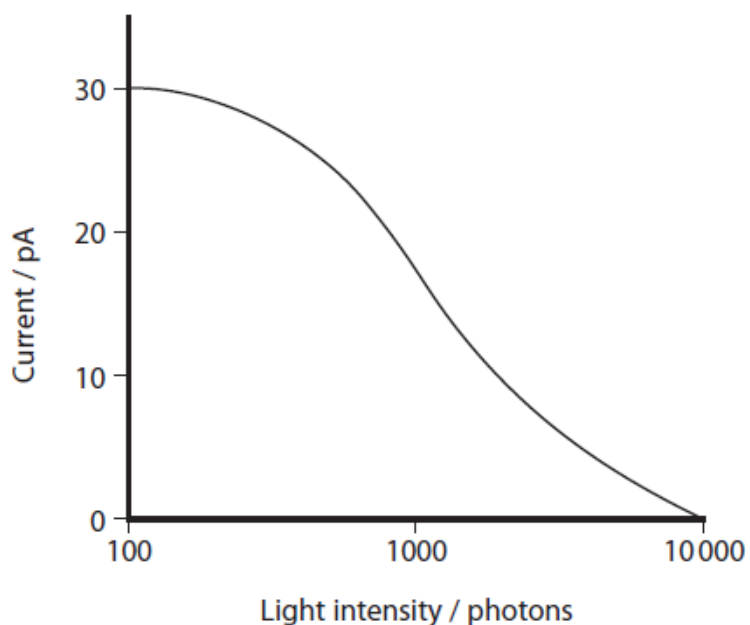
**(Total for question = 10 marks)**

Q3.

The retina of the human eye contains rod cells.  
These cells detect light energy as photons.  
The light energy is converted to a nerve impulse that is interpreted by the brain.

A current is produced by a rod cell when ions move through the cell surface membrane of a rod cell.

The graph shows the effect of increasing light intensity on the current produced by a rod cell.



Explain the effect of increasing light intensity on the current produced by a rod cell.

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**(Total for question = 5 marks)**

Q4.

The neurones of the central nervous system contain TAU proteins. These proteins help to maintain cell structure.

In humans, six different TAU proteins can be produced from a single gene.

Parkinson's disease has been linked to the different forms of the TAU proteins present in neurones.

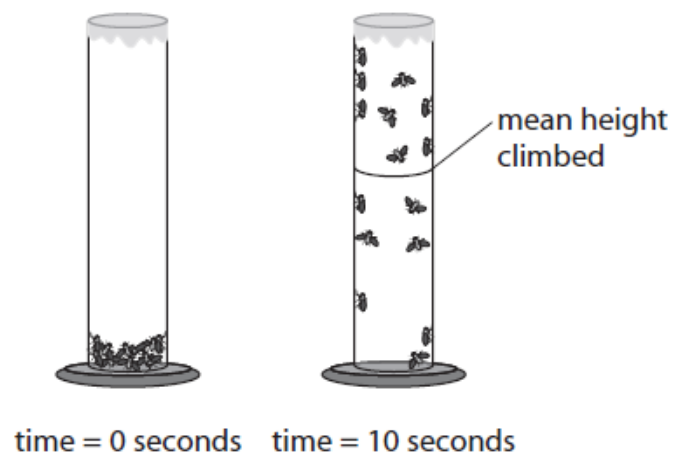
Scientists are studying the effect of these different TAU proteins in animal models.

One model used is the fruit fly, *Drosophila*.

In one investigation, the effect of ageing on *Drosophila* making different human TAU proteins was studied.

Flies making different forms of human TAU protein were tested in a climbing test.

- Fifteen one-day-old *Drosophila* flies were placed at the bottom of a measuring cylinder.
- A video recording was carried out and paused at 10 seconds. The height climbed by each fly was recorded.
- The test was repeated for flies of different ages.



The table shows the results of this investigation.

| Age of flies / days | Mean height climbed at 10 seconds / mm |                  |                  |
|---------------------|----------------------------------------|------------------|------------------|
|                     | Control (no human TAU protein)         | 0N3R TAU protein | 0N4R TAU protein |
| 1                   | 60 ± 6                                 | 52 ± 5           | 54 ± 5           |
| 7                   | 61 ± 4                                 | 43 ± 1           | 50 ± 4           |
| 14                  | 53 ± 3                                 | 18 ± 2           | 28 ± 8           |
| 21                  | 45 ± 9                                 | 12 ± 4           | 18 ± 5           |
| 28                  | 32 ± 8                                 | 10 ± 5           | 19 ± 1           |
| 35                  | 26 ± 9                                 | 3 ± 1            | 11 ± 1           |
| 42                  | 15 ± 3                                 | 1 ± 1            | 3 ± 1            |

Comment on the effect of TAU proteins on the ability of *Drosophila* flies to climb.

(3)

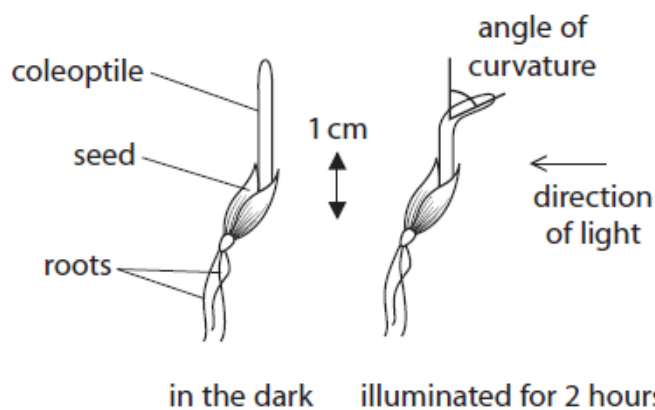
(Total for question = 3 marks)

Q5.

When oat seeds germinate, they produce roots and a coleoptile.

The effect of shading the tip of the coleoptile was investigated.

The diagram shows how the coleoptile of an oat seedling can bend towards light.



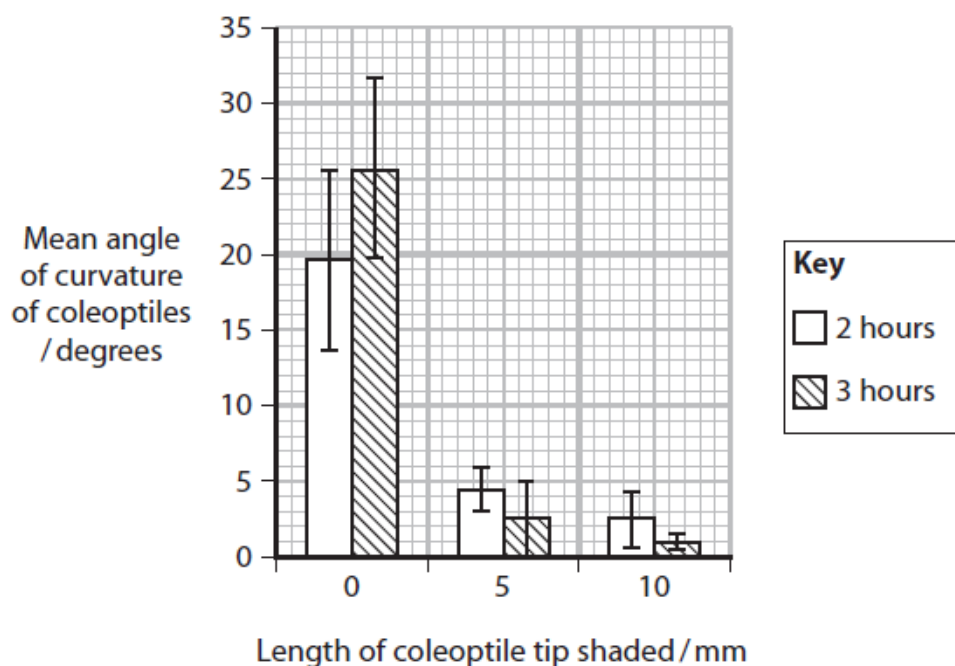
Oat seeds were germinated. When the coleoptiles were 2 cm long the seedlings were split into three groups.

- Group 1 none of the tip of the coleoptile was shaded
- Group 2 5 mm at the tip of the coleoptile was shaded
- Group 3 10 mm at the tip of the coleoptile was shaded

All the coleoptiles were then exposed to light from one side.

The curvature of the coleoptiles was measured after intervals of 2 hours and 3 hours.

The results of this investigation are shown in the graph.



(i) Describe two conclusions that can be drawn from the results of this investigation.

(2)

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(ii) The results of this investigation were analysed using the Student's t-test.

A p value of 0.05 was used to interpret the results of the t-test.

Explain what a p value of 0.05 means.

(2)

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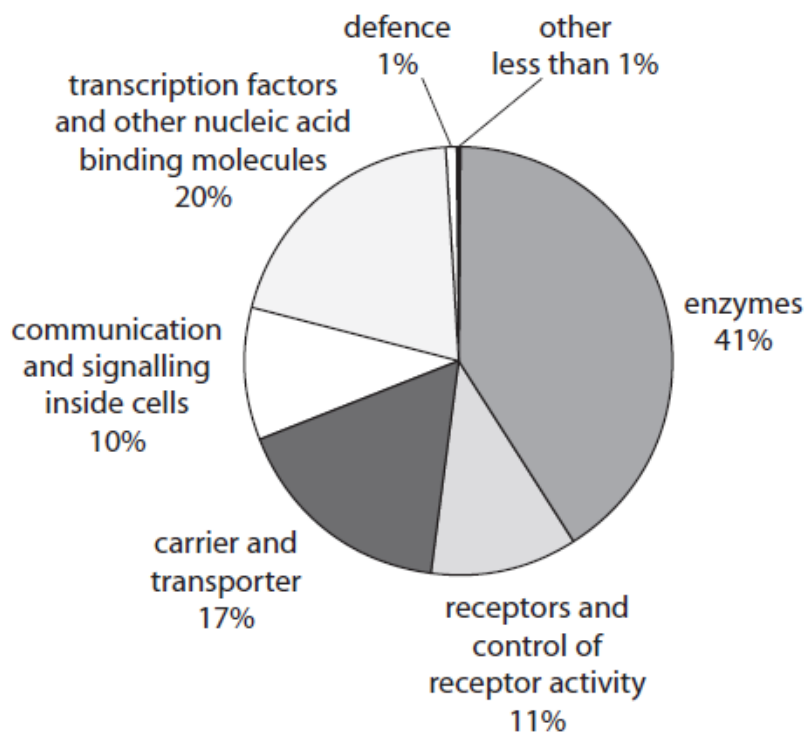
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**(Total for question = 4 marks)**

Q6.

\* The human genome codes for approximately 20 000 different proteins.

The pie chart shows the proportion of proteins carrying out different functions.



The 20 amino acids used to make proteins can be classified according to the properties of their side chains (R groups).

Table 1 shows the number of amino acids with these properties.

| Property of the side chain group | Number of amino acids with the property |
|----------------------------------|-----------------------------------------|
| Non-polar                        | 9                                       |
| Polar, uncharged                 | 6                                       |
| Negatively charged               | 3                                       |
| Positively charged               | 2                                       |

**Table 1**

Table 2 shows three amino acids, used to synthesise proteins, that have unique properties.

| Amino acid | Comment on structure                                                                                                                |
|------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Cysteine   | The side chain contains a thiol group (-S-H) that is chemically reactive.                                                           |
| Glycine    | The side chain is a hydrogen atom which is much smaller than any other side chain. This allows tight coiling of polypeptide chains. |
| Proline    | The side chain forms a peptide bond with the nitrogen in the amino group. This makes a polypeptide chain more rigid.                |

**Table 2**

Discuss the importance of the amino acid side chain to the structure, function and location of proteins.

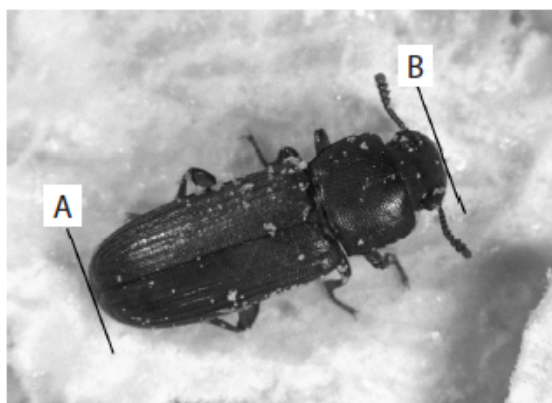
(9)

**(Total for question = 9 marks)**

Q7.

The red flour beetle (*Tribolium castaneum*) is a food pest found in flour.

The photograph shows a red flour beetle.



(Source: © Nigel Cattlin/Alamy Stock Photo)

magnification  $\times 15$

Calculate the length of the red flour beetle between A and B.

(1)

..... mm

**(Total for question = 1 mark)**

Q8.

The scientific article you have studied is from *Scientific American*.

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

question.

Describe how 'eyes relay visual information' to the brain (paragraph 2).

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**(Total for question = 5 marks)**

Q9.

Plants can respond to and use light.

The photograph shows a seedling starting to grow from a germinating seed.



Describe the role of IAA (auxin) in the phototropic response of plants.

(4)

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**(Total for question = 4 marks)**

The scientific article you have studied is from *Scientific American*.

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

Compare and contrast the structure of a sensory neurone and a motor neurone (paragraph 21).

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**(Total for question = 4 marks)**

Q11.

Acetylcholinesterase is an enzyme involved in regulating the transmission of nerve impulses across some synapses.

Alzheimer's disease is associated with the loss of neurones that produce acetylcholine.

It has been suggested that inhibitors of acetylcholinesterase may be useful in the treatment of Alzheimer's disease.

(i) Explain why inhibitors of acetylcholinesterase could be useful in the treatment of Alzheimer's disease.

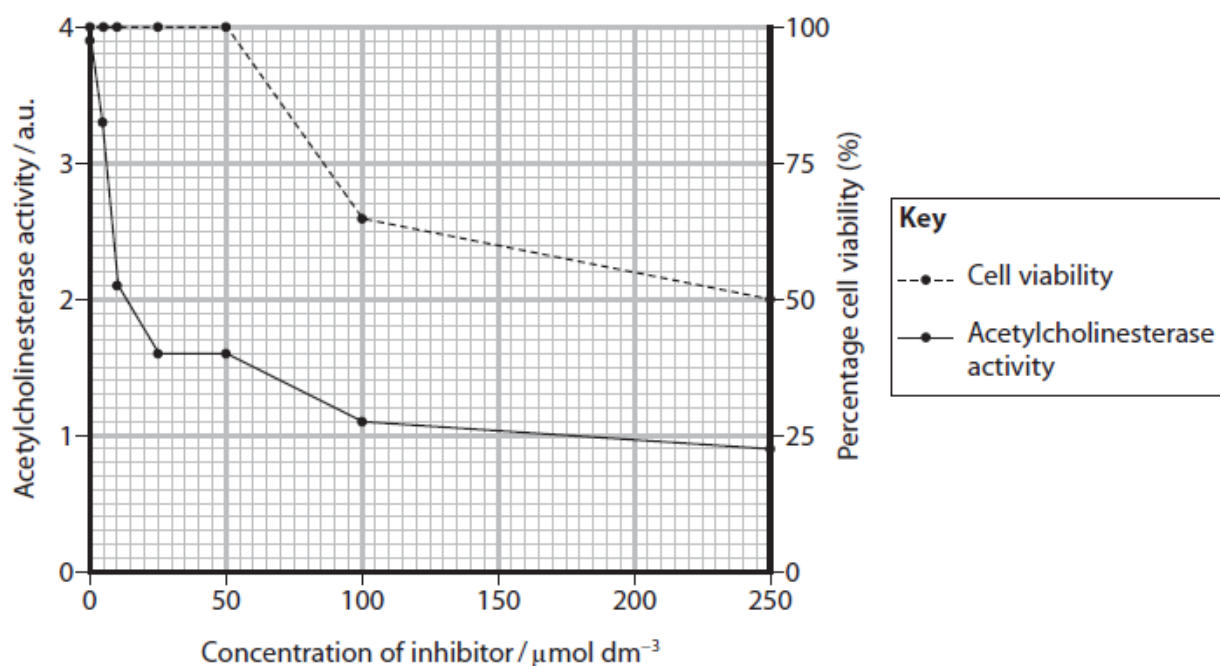
(3)

(ii) Trials of a new inhibitor were carried out using tissue cultures.

The effect of the concentration of the inhibitor on acetylcholinesterase activity and cell viability was measured.

Percentage cell viability was measured as the percentage of cells that were not killed by the inhibitor.

The graph shows the results for this inhibitor.



State and justify a suitable concentration of inhibitor to use in clinical trials.

(3)

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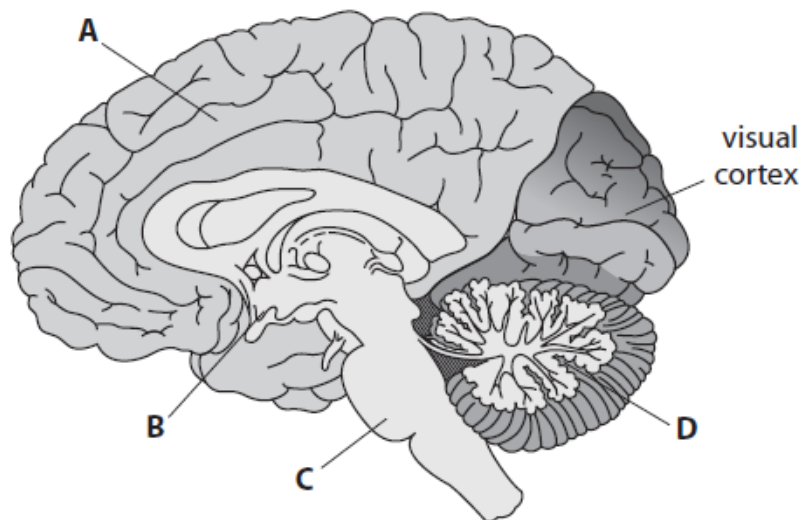
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**(Total for question = 6 marks)**

Q12.

Visual development requires exposure of the visual cortex to environmental signals during a critical period.

The diagram shows parts of the brain, including the visual cortex.



The visual cortex processes information received from the retina.

(i) The non-protein part of the light-absorbing pigment in the rod cells of the retina is called

**(1)**

- ☐ **A** IAA
- ☐ **B** opsin
- ☐ **C** retinal
- ☐

**D** rhodopsin

(ii) The part of the brain involved in interpreting the information processed in the visual cortex is

**(1)**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(iii) Explain how fMRI can be used to identify the part of the brain involved in interpreting information from the visual cortex.

**(3)**

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**(Total for question = 5 marks)**

Q13.

Glucosaminoglycans (GAGs) are the by-products of chemical reactions inside cells. GAGs are broken down by enzymes inside lysosomes in cells.

Mucopolysaccharidosis type I (MPS I) is a genetic condition that results in the build-up of GAGs inside cells.

MPS I affects the production of enzyme G that breaks down GAGs inside lysosomes.

More than 50 different mutations in the gene for enzyme G have been found to result in MPS I. Most of these mutations involve changing a single base in the gene.

A biotechnology company is developing a method of repairing the mutations in the gene for enzyme G.

The method being developed is called CRISPR-Cas9.

In this method, a short sequence of RNA binds to the DNA containing the mutation responsible for MPS I.

This RNA acts as a guide to enable the Cas9 enzyme to bind to DNA.

This enzyme can then cut and repair the DNA, removing the mutation.

(i) Describe how scientists could produce this short sequence of RNA needed to treat someone with MPS I.

(2)

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(ii) Explain why the use of CRISPR-Cas9 technology can be described as personalised medicine.

(2)

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**(Total for question = 4 marks)**

Q14.

An investigation was carried out to study the effect of positive and negative physical and emotional experiences on humans.

The positive physical experience was a warm object placed on the arm of a person for five seconds.

The negative physical experience was a hot object placed on the arm of a person for five seconds.

All other variables were kept constant.

Two groups of people were used in this investigation. In the first group, the warm object was used before the hot object. In the second group, the hot object was used before the warm object.

After each experience, the individuals were asked to rate their feelings using the scoring system below.

| Feelings  | Score |
|-----------|-------|
| Very bad  | 1     |
| Bad       | 2     |
| Neutral   | 3     |
| Good      | 4     |
| Very good | 5     |

Suggest why one group had the warm object placed on their arm before the hot object and the other group had the hot object placed on their arm first.

(2)

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Q15.

An investigation was carried out to study the effect of light on the mammalian retina.

Part of the retina of a young rat was removed and kept in the dark for two hours. This allowed the pigment in the rod cells to recover from bleaching caused by exposure to light.

Suggest what happens in the rod cells during this two hours of darkness.

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Q16.

**Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.**

There are many reasons why humans may lose muscle mass.

Two known causes are hip replacement surgery and some genetically inherited conditions.

Muscles can be scanned using magnetic resonance imaging (MRI) to investigate the loss of muscle mass.

It is safer to use MRI than computed tomography (CT) because

(1)

- ☐ **A** CT uses X-rays that can cause mutations in the DNA of muscle fibres
- ☐ **B** CT uses X-rays that can cause mutations in the protein in the muscle fibres
- ☐ **C** CT uses magnets that can cause mutations in the DNA of muscle fibres
- ☐ **D** CT uses magnets that can cause mutations in the protein in the muscle fibres

(Total for question = 1 mark)

## Mark Scheme

Q1.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                          | Additional guidance                                                                             | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|------------|
|                 | <p>A description that makes reference to two of the following:</p> <ul style="list-style-type: none"><li>• period of time during early development (1)</li><li>• when the nervous system must obtain specific experiences to develop properly (1)</li><li>• so that synapses are strengthened / unstimulated synapses are removed (1)</li></ul> | <p>ALLOW retina needs to be exposed to light</p> <p>ALLOW when visual columns are organised</p> | <p>(2)</p> |

Q2.

| Question Number | Answer                                                                                                                                                                                                                                                       | Additional Guidance                                                                                                                                                  | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <ul style="list-style-type: none"> <li>calculation of { largest difference in concentration / largest value at 0 minutes and smallest value at 30 minutes } (1)</li> <li>calculation of rate of decrease in nicotine concentration per minute (1)</li> </ul> | <p>Example of calculation</p> $(35.0 + 9.3) / 44.3 \text{ and } (24.1 - 5.6) / 18.5$<br>$25.8 \div 30 = 0.86$ <p>Correct answer without working gains full marks</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional Guidance                                                                       | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|------|
| (ii)            | <p>An answer that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>percentage change greater for {the lower concentration of / 0.1 mg } nicotine (1)</li> <li>a higher concentration causes a positive (percentage) change whilst the lower concentration leads to a negative (percentage) change (1)</li> <li>correct calculation of percentage change for both rat groups (1)</li> </ul> | <p>2.08% for { 1.0 mg nicotine / group A } and 6.25% for { 0.1mg nicotine / group B }</p> | (2)  |

| Question Number | Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *(iii)          | <p>Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant.</p> <p>Give examples of relevant biological knowledge and understanding:</p> <p><u>Validating the statement</u></p> <ul style="list-style-type: none"> <li>Investigation involved rats inhaling nicotine which humans do during smoking</li> <li>Rats are mammals so can extrapolate to humans</li> </ul> <p><u>Not validating the statement</u></p> <ul style="list-style-type: none"> <li>Nicotine inhaled (for both nicotine concentrations) leads to vasoconstriction and then vasodilation and then returns to original diameter</li> <li>Blood pressure for 1mg nicotine concentration increases and decreases but drops below original value</li> <li>Presence of nicotine leads to noradrenaline release which increases heart rate</li> <li>Blood pressure (for both nicotine concentrations) increases and decreases</li> <li>No reference to rats inhaling smoke, only nicotine</li> <li>Rats are not the same as humans</li> <li>Sample size too small to make a valid statement</li> </ul> <p><u>Comment</u></p> <ul style="list-style-type: none"> <li>whether agree or disagree with statement</li> </ul> |

|                |       |                                                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                                                                                                                         |
|----------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Level 0</b> | Marks | No awardable content                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                             |
| <b>Level 1</b> | 1-2   | <p>Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified.</p> <p>A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.</p>                                      | <p>An answer that refers to just one piece of evidence – either lumen size or blood pressure</p> <p>Simple conclusion drawn from the evidence</p>                                                                                                                                           |
| <b>Level 2</b> | 3-4   | <p>A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified.</p> <p>A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.</p>                            | <p>An answer that refers to evidence concerning both lumen size and blood pressure</p> <p>Links made between lumen size, vasoconstriction and blood pressure</p>                                                                                                                            |
| <b>Level 3</b> | 5-6   | <p>A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information.</p> <p>A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.</p> | <p>An answer that refers to data about vasoconstriction and vasodilation and links it to effect of nicotine on the release of noradrenaline and therefore on blood pressure</p> <p>Conclusion made considering validity of data collected from rats and how it can be applied to humans</p> |

Q3.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional Guidance                                                                                                                                                                           | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>increasing light intensity decreases the current (1)</li> <li>because {rhodopsin is broken down / opsin is released} (1)</li> <li>therefore, more opsin binds to the channel proteins in the outer segment (1)</li> <li>sodium-gated voltage channels close (1)</li> <li>{reducing / stopping} the influx of sodium ions / making membrane impermeable to sodium ions (1)</li> </ul> | <p>ALLOW opsin binds to the cell surface membrane / sodium-gated voltage channels</p> <p>ALLOW Na<sup>+</sup> channels / (non-specific) cation channels for sodium-gated voltage channels</p> | (5)  |

Q4.

| Question number | Answer                                                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                   | Mark                              |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
|                 | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>as they age Drosophila climb {less high / more slowly} (1)</li> <li>(the expression of) 0N3R or 0N4R further {reduce the height climbed / slow down} the Drosophila (1)</li> <li>033R has a greater effect than 0N4R (1)</li> </ul> | <p>ALLOW tau proteins / both tau proteins reduced height climbed</p> <p>ALLOW fly in place of climb</p> <p>ALLOW 033R affected the flies the most</p> | <p>Choose an item.</p> <p>(3)</p> |

Q5.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                                          | Mark          |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| (i)             | <p>A description that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>shading (coleoptile tip) reduces / stops bending (1)</li> <li>light {detecting / sensitive} part of coleoptile is in first 5 mm (1)</li> <li>no (significant) difference between {(exposure for) 2 or 3 hours / (shading of) 5 mm or 10 mm} (1)</li> </ul> | <p>ALLOW as (length of) shading increases degree of bending decreases<br/>ALLOW converse</p> <p>ALLOW part of coleoptile that bends is below the part that detects light</p> | Expert<br>(2) |

| Question number | Answer                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                          | Mark          |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| (ii)            | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>{5% / 1 in 20} probability (1)</li> <li>the results (obtained) occurred by chance (1)<br/>OR</li> <li>95% probability (1)</li> <li>the results (obtained) did not occur by chance (1)</li> </ul> | <p>IGNORE reference to null hypothesis<br/>ALLOW less than 5%<br/>ALLOW probability of 0.05</p> <p>DO NOT ALLOW results are {accurate / correct / wrong}</p> | Expert<br>(2) |

Q6.

| Question number |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *               | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p><b>Indicative content</b></p> <p>Information</p> <ul style="list-style-type: none"> <li>• there are 20 000 different proteins</li> <li>• these proteins carry out different functions</li> <li>• there are a {large number of / 20} different {R groups / amino acids}</li> <li>• most R groups are non-polar, some are polar a few have a charge</li> </ul> <p>Linkage to <b>structure</b></p> <ul style="list-style-type: none"> <li>• R groups determine {3D shape / structure} of proteins</li> <li>• {large number of / 20 R groups}</li> <li>• many combinations of amino acids required to give wide variety of protein structures</li> <li>• R groups can form bonds to stabilise 3D structure (e.g. cysteine)</li> <li>• role of R-groups in structure of haemoglobin</li> <li>• role of R-groups in structure of collagen</li> <li>• location of cysteine allows formation of disulfide bonds</li> </ul> <p>Linkage to <b>function</b></p> <ul style="list-style-type: none"> <li>• R groups variety of protein shapes are required to allow proteins to carry out wide range of functions</li> <li>• examples of functions that require specific structure e.g. antibodies specific to an antigen / enzymes specific for a substrate / receptors e.g. neurotransmitters and (acetylcholine) and ion-gated channels</li> <li>• polar / ionic R groups increase solubility</li> <li>• non-polar R groups will be on outside of insoluble proteins / structural proteins / collagen / proteins inserted into membranes</li> <li>• role of R-groups in function of haemoglobin</li> <li>• role of R-groups in function of collagen</li> </ul> <p>Linkage to <b>location</b></p> <ul style="list-style-type: none"> <li>• polar R groups will be in aqueous environment / non-polar regions in a non-aqueous environment</li> </ul> |

|  |                                                                                                                                                                                                                                                                                                                                                                                      |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <ul style="list-style-type: none"> <li>• polar / ionic R groups soluble in {plasma/ tissue fluid / cytoplasm} / line the inside of ion channels / found on the outside of soluble proteins such as hormones / transport proteins / immunoglobulins / cytokines</li> <li>• role of R-groups in location of haemoglobin</li> <li>• role of R-groups in location of collagen</li> </ul> |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| Level | Marks |                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                              |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | 0     | No awardable content                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                              |
| 1     | 1-3   | Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. | Selection of some information from the table – little or no linkage<br><br>Linkage to one aspect – 2 marks<br>Two linkages for same aspect – 3 marks                                         |
| 2     | 4-6   | Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.                                          | Linkage between R groups and two aspects from structure, function and location<br><br>One comment on each - 4 marks<br>An additional comment - 5 marks<br>An additional 2 comments – 6 marks |
| 3     | 7-9   | Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.                                                                                                                     | Linkage between R groups and all three aspects (structure, function and location)<br><br>One comment on each - 7 marks                                                                       |

|  |  |                                                                                                                           |                                                                       |
|--|--|---------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
|  |  | The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. | An additional comment - 8 marks<br>An additional 2 comments – 9 marks |
|--|--|---------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|

Q7.

| Question number | Answer                                                                        | Additional guidance | Mark            |
|-----------------|-------------------------------------------------------------------------------|---------------------|-----------------|
|                 | <ul style="list-style-type: none"> <li>• correct length calculated</li> </ul> | 3.3 / 3.33          | Clerical<br>(1) |

Q8.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional guidance                                                       | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|------|
|                 | <p>A description that makes reference to five of the following:</p> <ul style="list-style-type: none"> <li>• light is detected by rod cells (1)</li> <li>• rod cell membrane is hyperpolarised (1)</li> <li>• stopping the release of the inhibitory neurotransmitter glutamate (1)</li> <li>• bipolar neurone is depolarised (1)</li> <li>• impulse transmitted along {ganglion neurone / optic nerve} (1)</li> <li>• (impulse transmitted) to visual cortex of the brain (1)</li> </ul> | <p>ALLOW description of role of rhodopsin</p> <p>ALLOW occipital lobe</p> | (5)  |

Q9.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                                                     | Mark                              |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
|                 | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• (IAA) produced in the tip of the shoot (1)</li> <li>• (IAA) accumulates on the dark side of the shoot (1)</li> <li>• (IAA) stimulates cell elongation (1)</li> <li>• causing the shoot to grow towards the light source (1)</li> </ul> | <p>ALLOW a diffusion gradient is established / IAA diffuses to the opposite side of the shoot</p> <p>ALLOW low concentrations of IAA inhibit cell elongation on the light side</p> <p>ALLOW plant</p> <p>ALLOW bend</p> | <p>Choose an item.</p> <p>(4)</p> |

Q10.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                          | Additional guidance                                                                                                                                                          | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|                 | <p>An answer that makes reference to the following:</p> <p>Similarities</p> <ul style="list-style-type: none"> <li>• both have a cell body containing a nucleus (1)</li> <li>• both have an axon (1)</li> <li>• both have dendrites at one end of neurone and terminal branches at the other end (1)</li> </ul> <p>Difference</p> <ul style="list-style-type: none"> <li>• location of cell body (1)</li> </ul> | <p>IGNORE descriptions of function</p> <p>ALLOW motor neurone cell body is at one end of the axon whereas in the sensory neurone the cell body is located along the axon</p> | <p>(4)</p> |

Q11.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional guidance                                                                                                                                     | Mark                              |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| (i)             | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>acetylcholinesterase breaks down acetylcholine (1)</li> <li>inhibitor prevents break down of acetylcholine (1)</li> <li>so more (acetylcholine) is available to bind to post-synaptic {membrane / receptors} (1)</li> <li>therefore compensating for the {reduced production of acetylcholine / loss of acetylcholine producing neurones} (1)</li> </ul> | <p>ALLOW blocks acetylcholinesterase</p> <p>ALLOW inhibiting acetylcholinesterase maintains higher concentrations of acetylcholine (in synapse) (1)</p> | <p>Choose an item.</p> <p>(3)</p> |

| Question number | Answer                                                                                                                                                                                                                                                                                            | Additional guidance                                                                                                                                                                         | Mark                              |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| (ii)            | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>concentration between 25 and 50 <math>\mu\text{mol dm}^{-3}</math> (1)</li> <li>concentration having greatest inhibitory effect (1)</li> <li>but having no effect on cell viability (1)</li> </ul> | <p>ALLOW any value between 25 and 50</p> <p>ALLOW suitable description of effect e.g. reduces enzyme activity by {more than 50% / 60% / 2.4 a.u.</p> <p>ALLOW viability remains at 100%</p> | <p>Choose an item.</p> <p>(3)</p> |

Q12.

| Question Number | Answer                                                                                                                                                                                                                                                                      | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (i)             | <p><b>C</b> - retinal</p> <p><i>The only correct answer is C</i></p> <p><b>A</b> is incorrect because IAA is auxin</p> <p><b>B</b> is incorrect because opsin is the protein part and not the non-protein</p> <p><b>D</b> is incorrect because rhodopsin is the pigment</p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                            | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (ii)            | <p><b>A</b></p> <p><i>The only correct answer is A</i></p> <p><b>B</b> is incorrect because it is the hypothalamus</p> <p><b>C</b> is incorrect because it is the medulla oblongata</p> <p><b>D</b> is incorrect because it is the cerebellum</p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional Guidance                      | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------|
| (iii)           | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>• (fMRI) detects { blood flow / oxygen use } in the brain</li> <li>• increased brain activity results in increased { blood flow / demand for oxygen / aerobic respiration } in the area of activity</li> <li>• oxyhaemoglobin absorbs fewer radio waves / fMRI detects areas where less signal absorbed</li> </ul> | ALLOW signal reflected by oxyhaemoglobin | (3)  |

Q13.

| Question Number | Answer                                                                                                                                                                                                                                                             | Additional Guidance | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (i)             | <p>An answer that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>• transcription (of the DNA containing the mutation) / transcribe to produce { mRNA / RNA }</li> <li>• using { RNA nucleotides / RNA polymerase }</li> </ul> | IGNORE translation  | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                            | Additional Guidance               | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------|
| (ii)            | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>individuals have different mutations / targets an individual's specific mutation</li> <li>the RNA molecule used will be specific to { each mutation / individual }</li> </ul> | ALLOW mutations at different loci | (2)  |

Q14.

| Question Number | Answer                                                                                                                                                                                                                        | Additional Guidance                                                                                                                       | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------|
|                 | <p>1. idea that there was no bias ;</p> <p>2. idea of contributes to validity ;</p> <p>3. idea of hot object desensitises ;<br/>OR<br/>idea of thermoreceptors not harmed /overstimulated / habituated due to high temp ;</p> | <b>1. ACCEPT</b> sequence of procedure has no effect/to see if positive then negative gives a different outcome to negative then positive | (2)  |

Q15.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                  | Additional Guidance                                                                                                                                                                                                                                                                                                                  | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|                 | 1. idea that opsin uncouples from the (rod cell) cell surface membrane ;<br>2. trans retinal {converts / eq} to cis retinal ;<br>3. rhodopsin is (re)formed / eq ;<br>4. from opsin and retinal ;<br>5. idea that this results in dark adaptation ;<br>6. permeability of the cell surface membrane to $\text{Na}^+$ increases / eq ;<br>7. hyperpolarisation of cell decreases / eq ;<br>8. (more) neurotransmitter is released / eq ; | <b>NB IGNORE references to bipolar neurone responses</b><br><b>IGNORE</b> reference to retinol<br><br><br><br><br><br><br><b>6. ACCEPT</b> $\text{Na}^+$ {enters /channels unblocked / channels open}<br><b>7. ACCEPT</b> (partial) depolarisation / reduced potential difference<br><b>8. ACCEPT</b> glutamate for neurotransmitter | <b>(5)</b> |

Q16.

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                           | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|                 | The only correct answer is <b>A</b> – CT uses X-rays that can cause mutations in the DNA of muscle fibres<br><br><b>B</b> is incorrect because mutations do not occur in protein<br><br><b>C</b> is incorrect because CT does not use magnets<br><br><b>D</b> is incorrect because CT does not use magnets and mutations do not occur in protein | <b>(1)</b> |