PEARSON EDEXCEL A-LEVEL BIOLOGY A · 9BN0

BIOLOGY



EXAM QUESTION PACK

TOPIC 8: GREY MATTER

SCORE	PERCENTAGE
/582	%

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.

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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.

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(Total for question = 3 marks)

Q4.

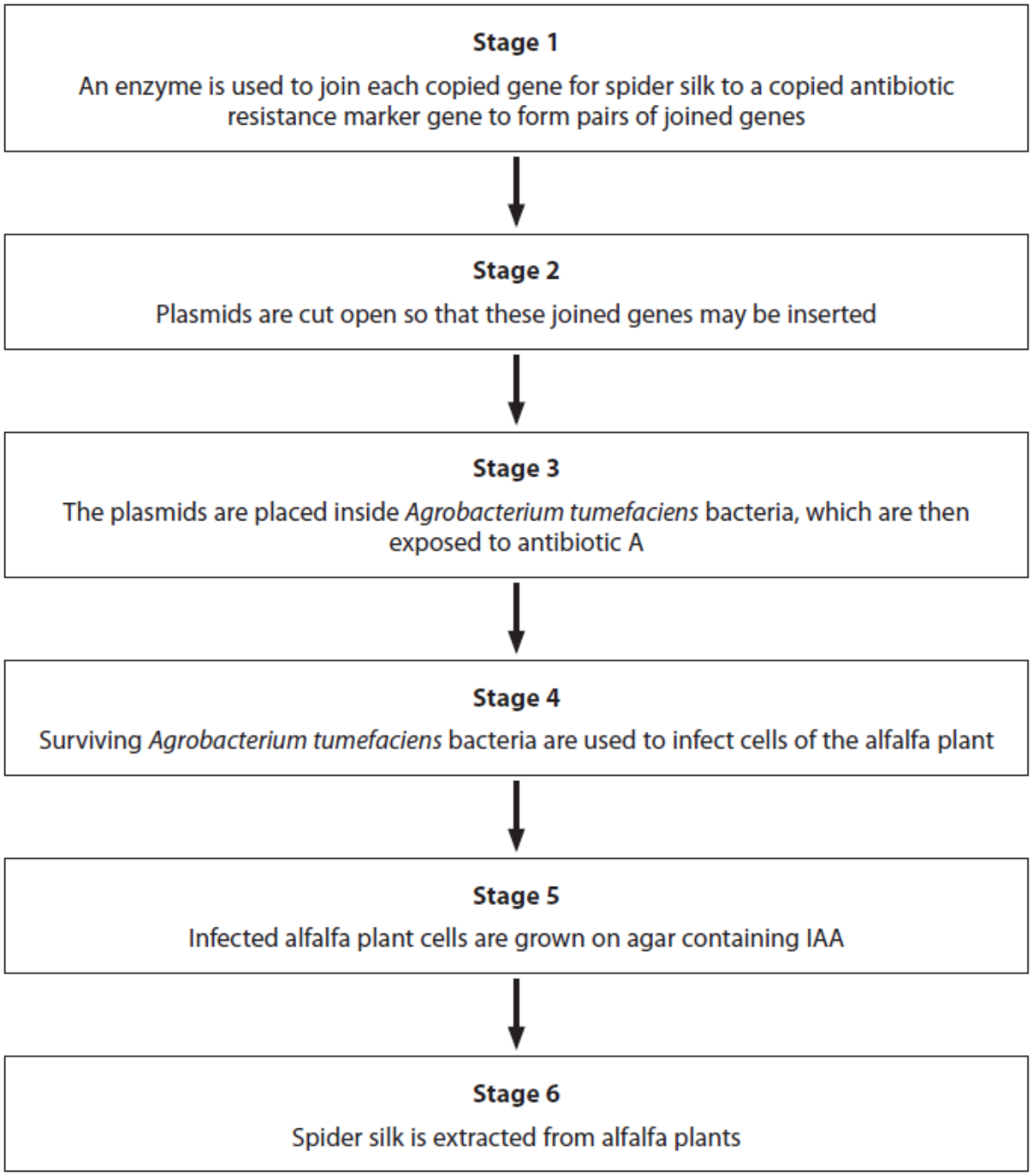
Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

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.

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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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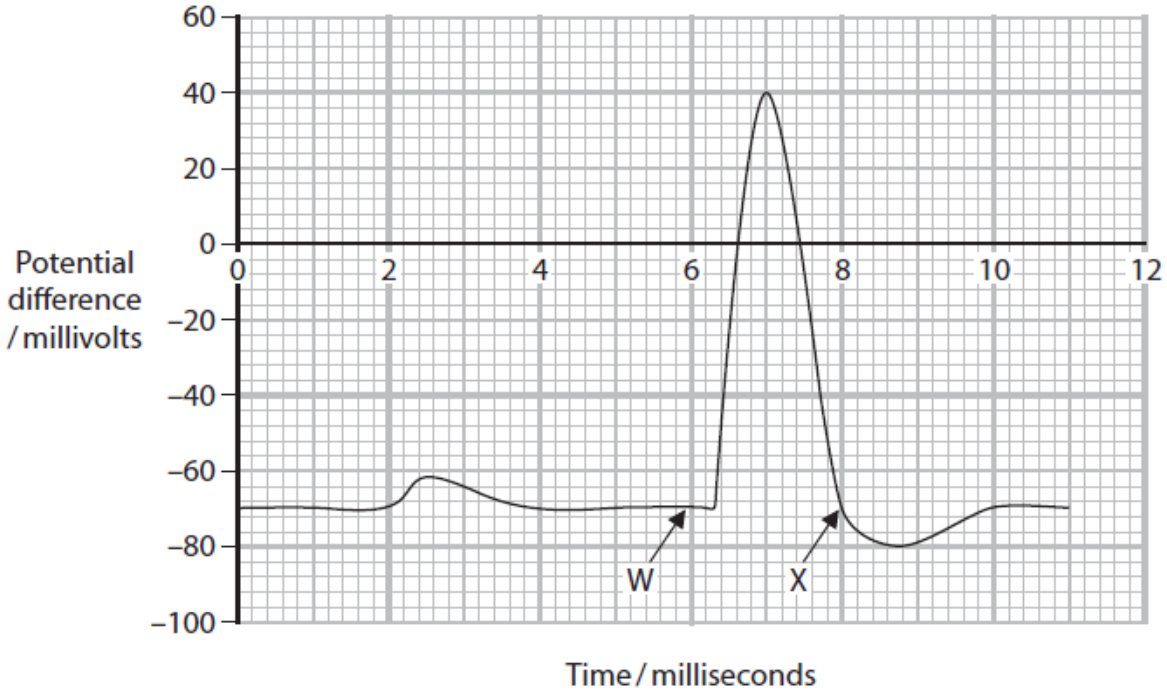
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(Total for question = 4 marks)

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

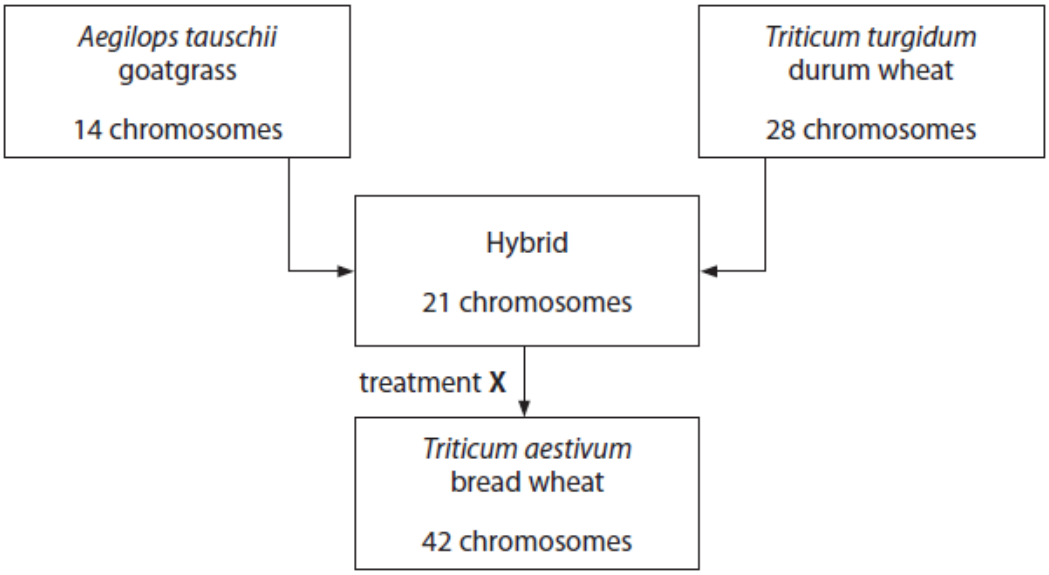


Triticum turgidum
Genomes A and B



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).

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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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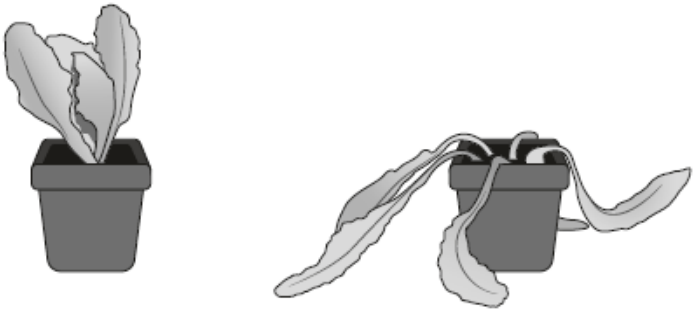
(Total for question = 2 marks)

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.

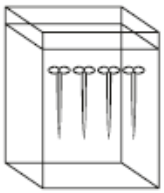
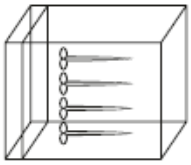
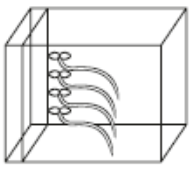
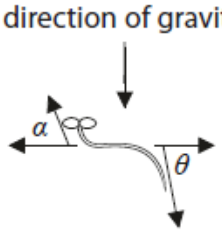
These two phenotypes are shown in the diagram.



Upright Weary

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.

Stage A 	Lettuce plants were grown until their stems were 15 cm long.
Stage B 	The lettuce plants were then placed in complete darkness and rotated so that they were at 90° to the direction of gravity.
Stage C  	The curvatures of the stems (α) and roots (θ) were measured for the next 23 days.

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

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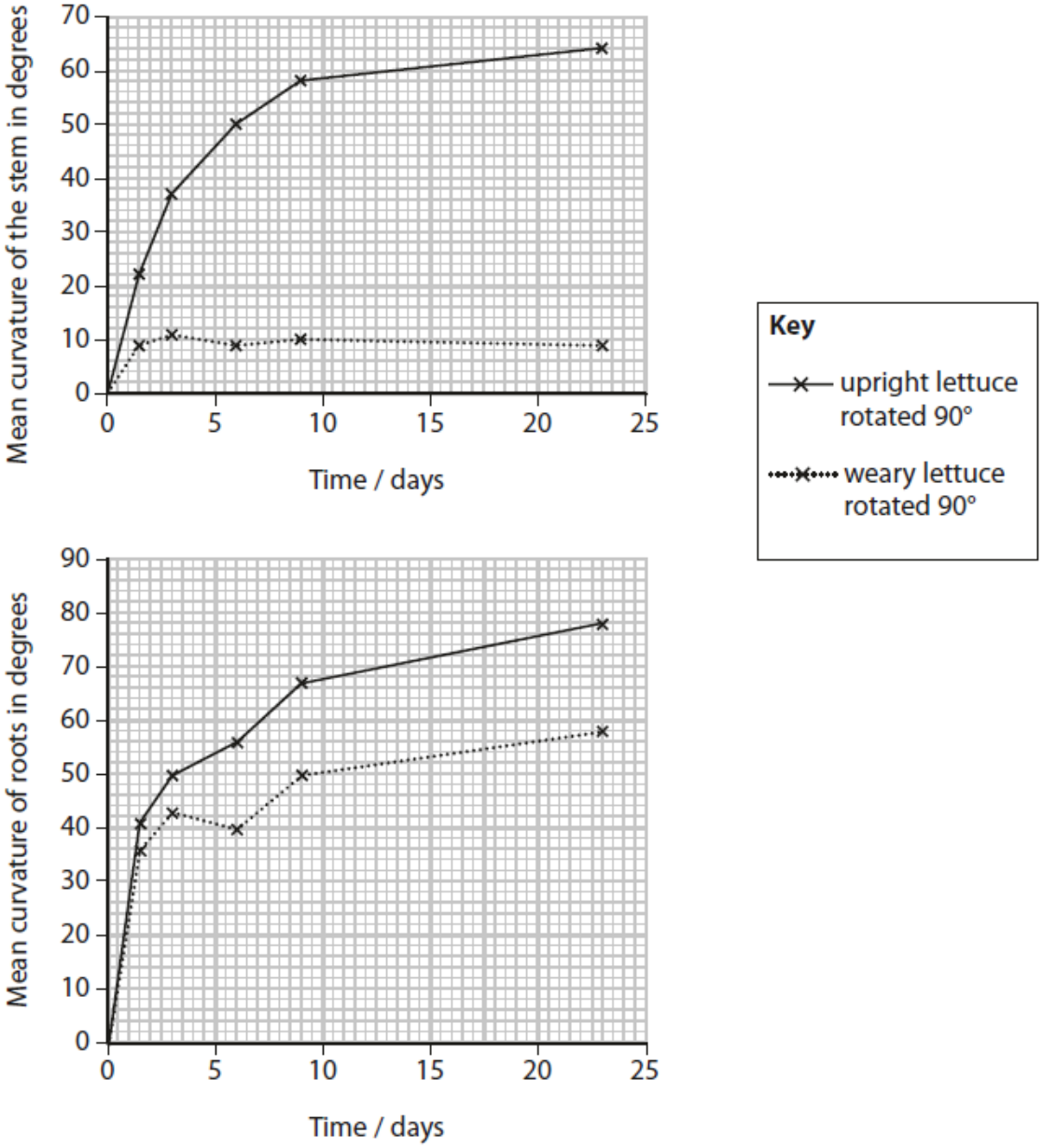
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(ii) The mean curvatures of the stems and the roots are shown in the graphs.



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

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Answer .....

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

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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)

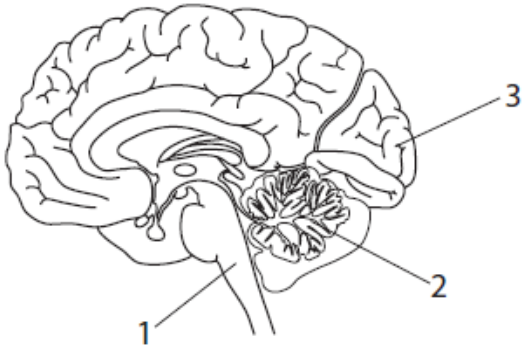


Diagram A

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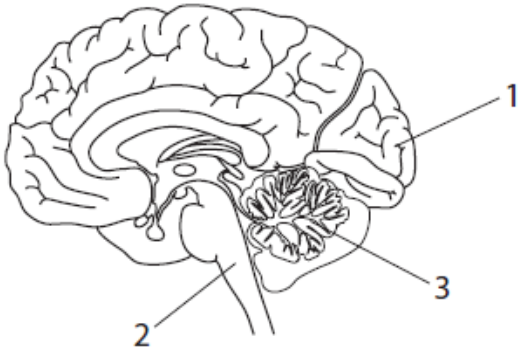


Diagram B

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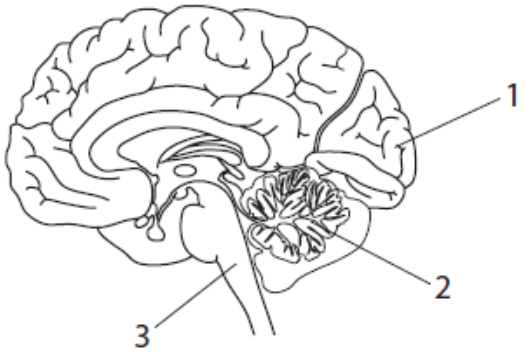


Diagram C

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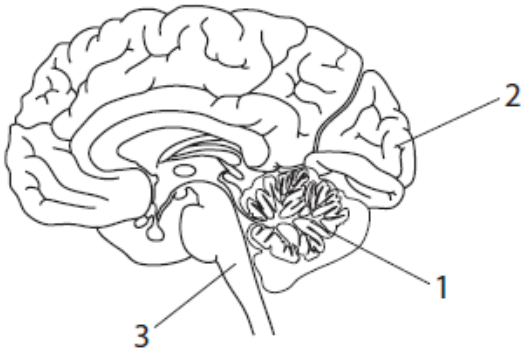


Diagram D

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(Total for question = 1 mark)

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)

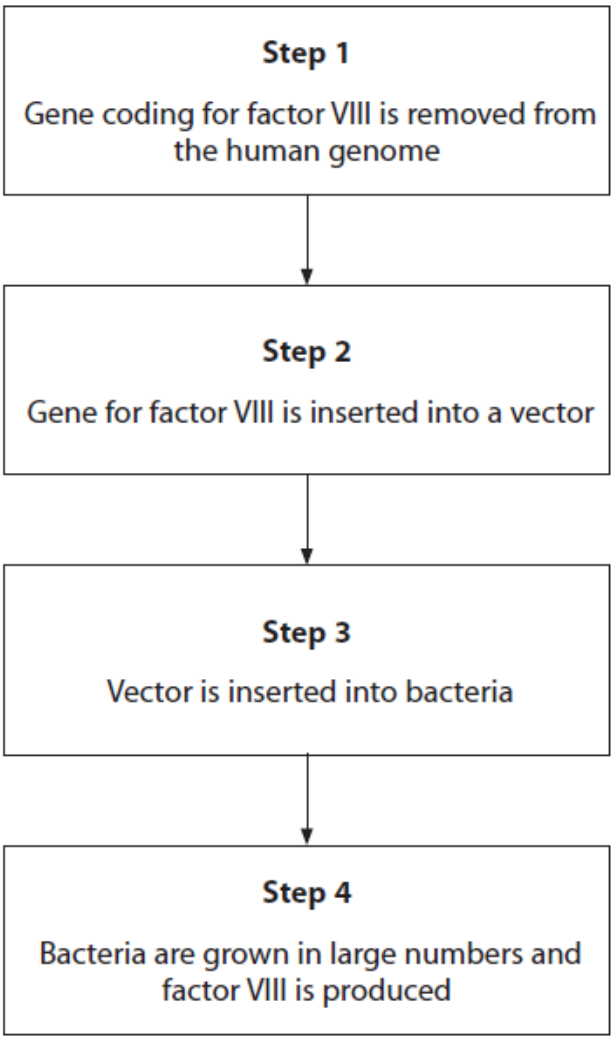
Q22.

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.

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

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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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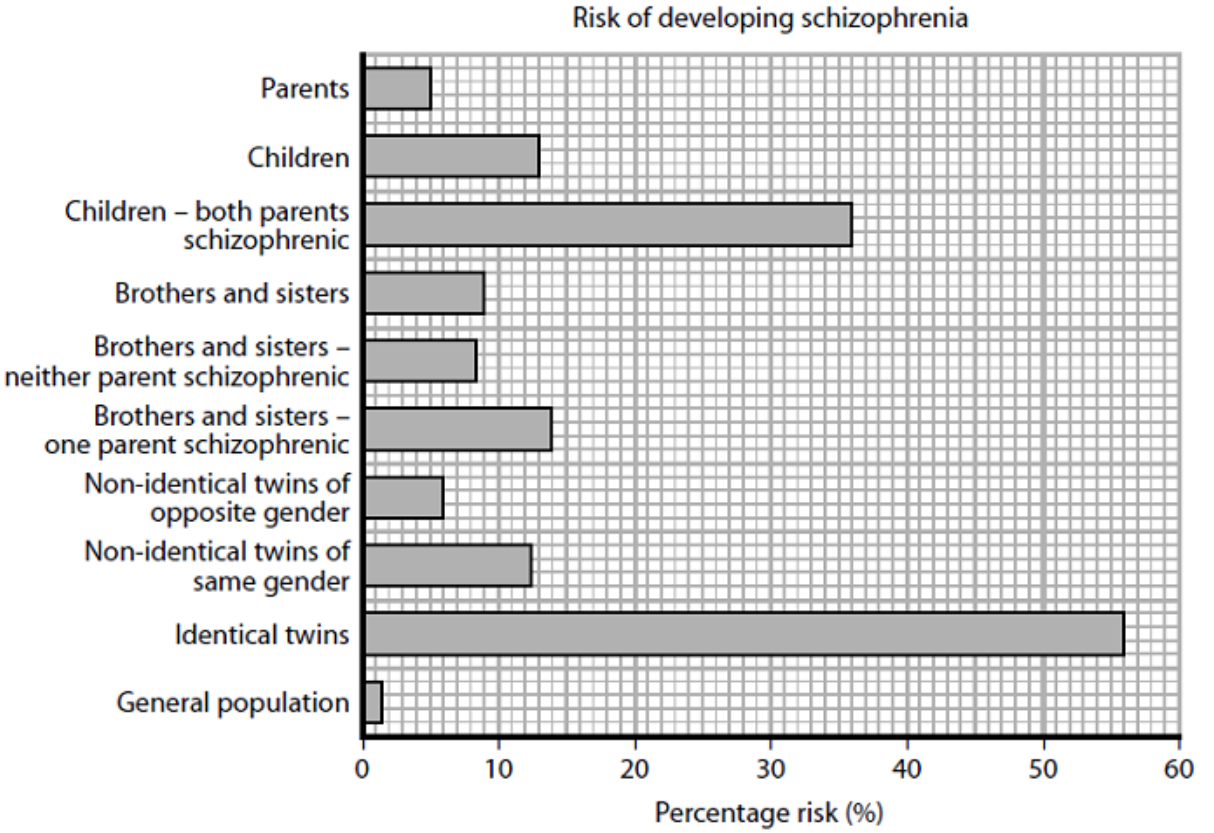
(Total for question = 9 marks)

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.



© Courtesy of Dr. Debby Tsuang, University of Washington/VAPuget Sound Health Care System, Seattle, WA, USA.

(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.

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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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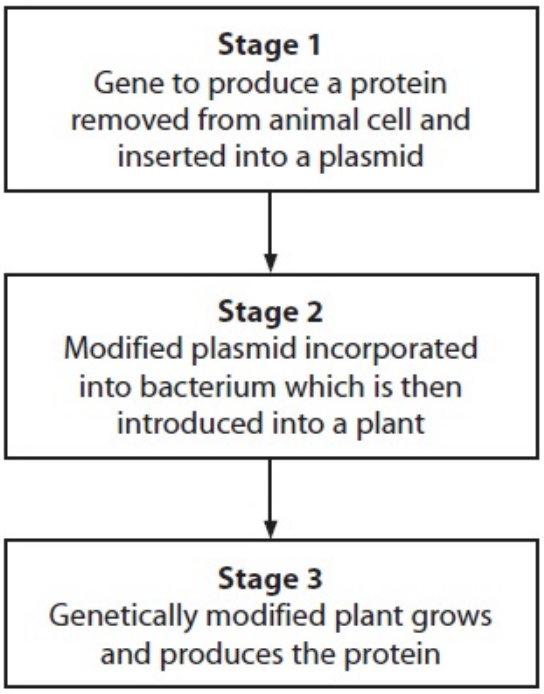
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(Total for question = 11 marks)

Q24.

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.

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

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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).

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(Total for question = 1 mark)

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
☒ **A**	no	no	yes
☒ **B**	no	yes	yes
☒ **C**	yes	yes	no
☒ **D**	yes	yes	yes

(Total for question = 2 marks)

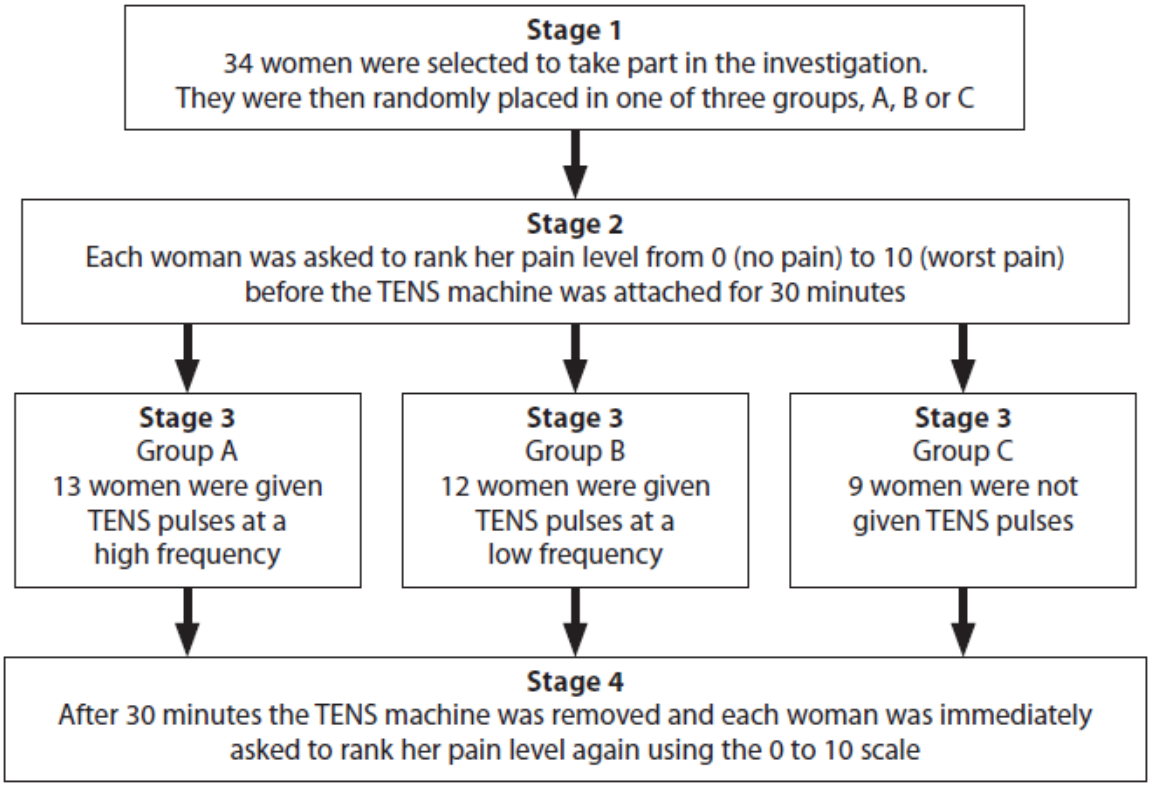
Q2.

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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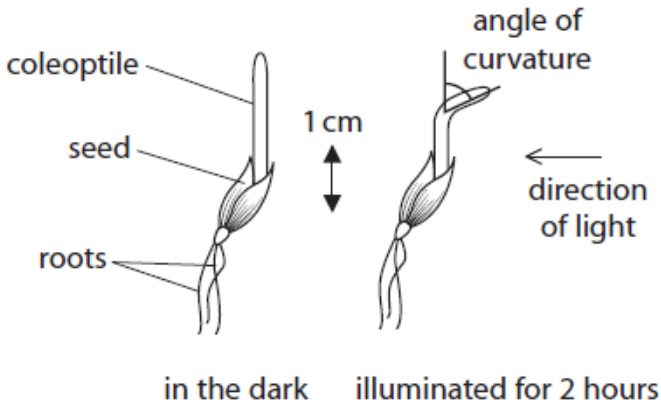
(Total for question = 8 marks)

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.



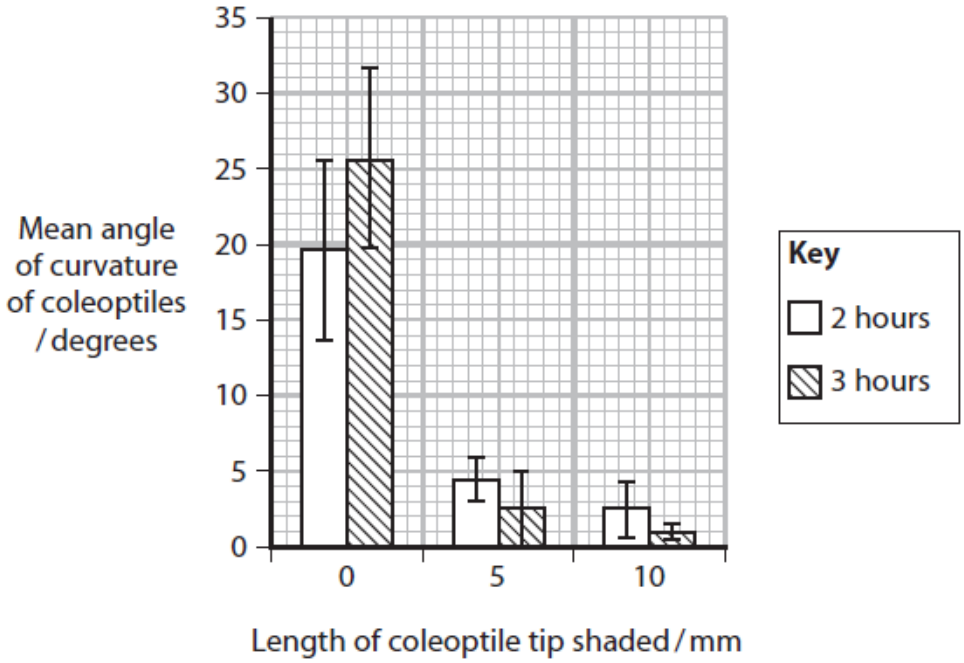
Oat seeds were germinated. When the coleoptiles were 2 cm long the seedlings were split into three groups.

- 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.

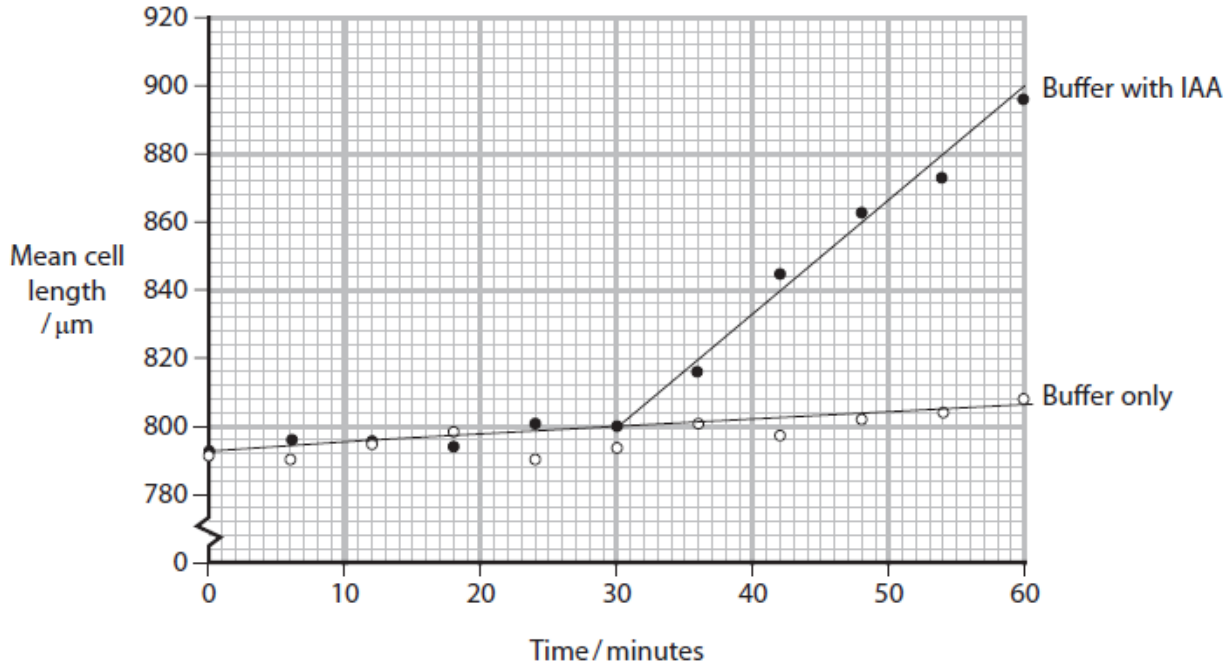


In a second investigation, cells were taken from below the tip of the coleoptile.

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)

Q6.

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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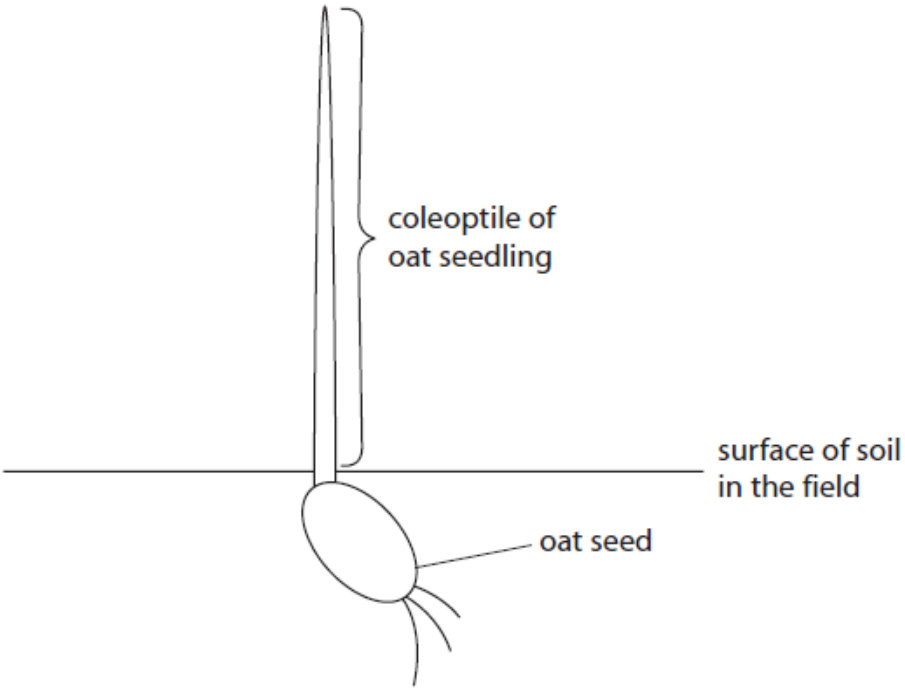
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(Total for question = 2 marks)

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.

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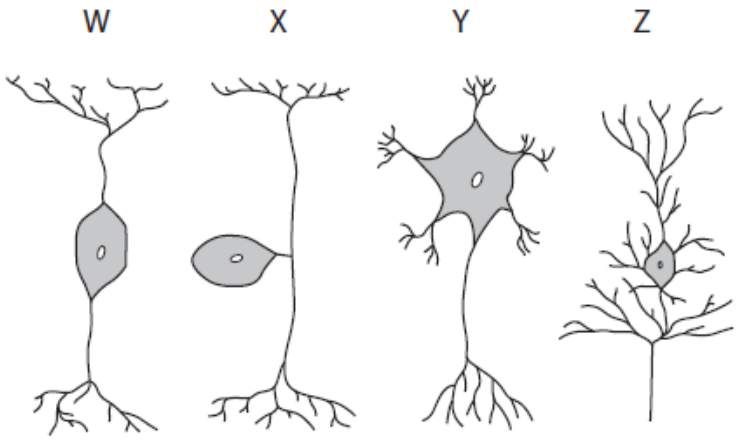
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(Total for question = 4 marks)

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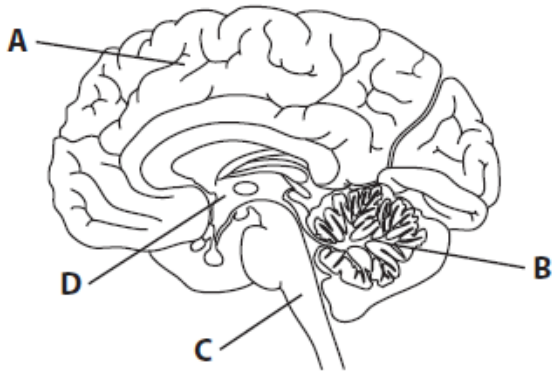
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(ii) It was found that an area of the brain called the insula was involved in both physical experiences and emotional experiences. The insula is found just above the hypothalamus.

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.

(2)

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)

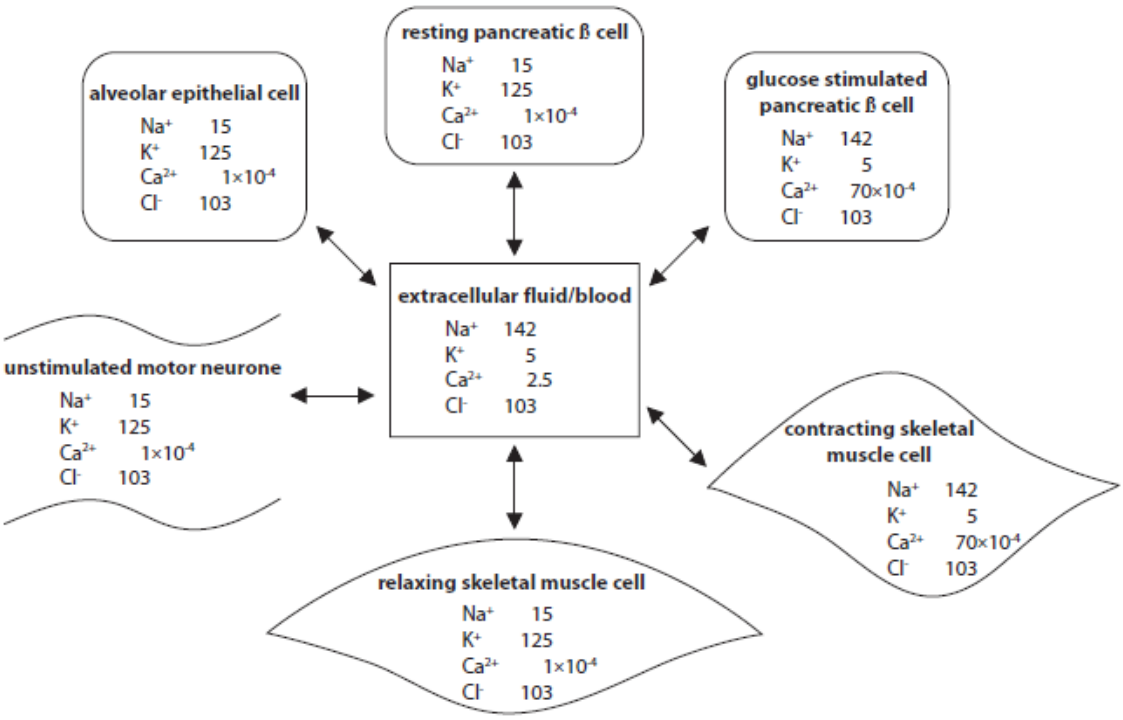
Q12.

*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 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.

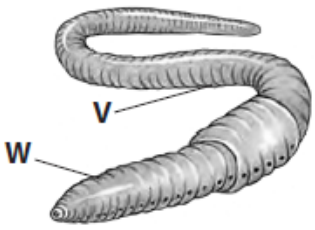
The duration of the withdrawal response is the length of time that the muscles remain contracted. If the stimulus is repeated, the withdrawal response is either reduced in duration or lost.

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**.

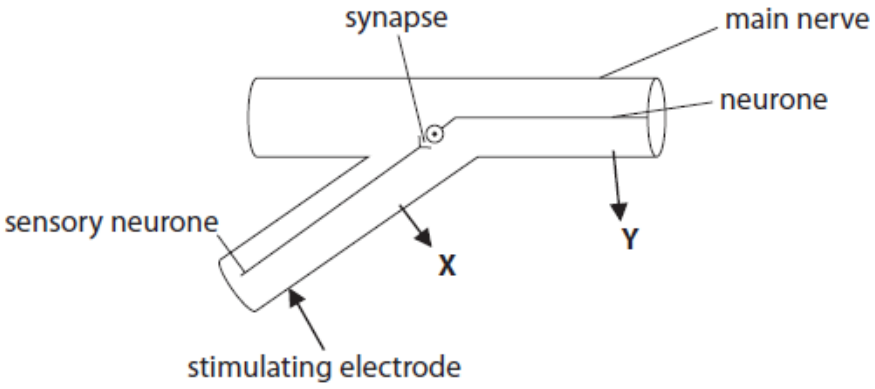
The results of this study are shown in the table.

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

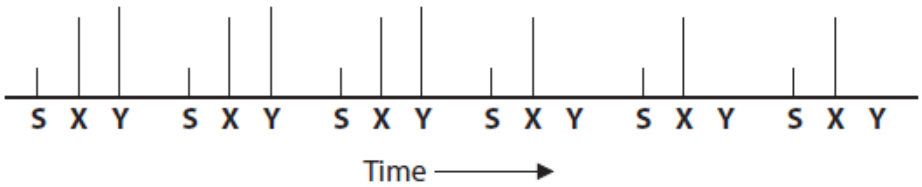


In another study, sensory neurones of an earthworm were stimulated by an electrode six times.

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)

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

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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.

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(Total for question = 2 marks)

Q15.

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

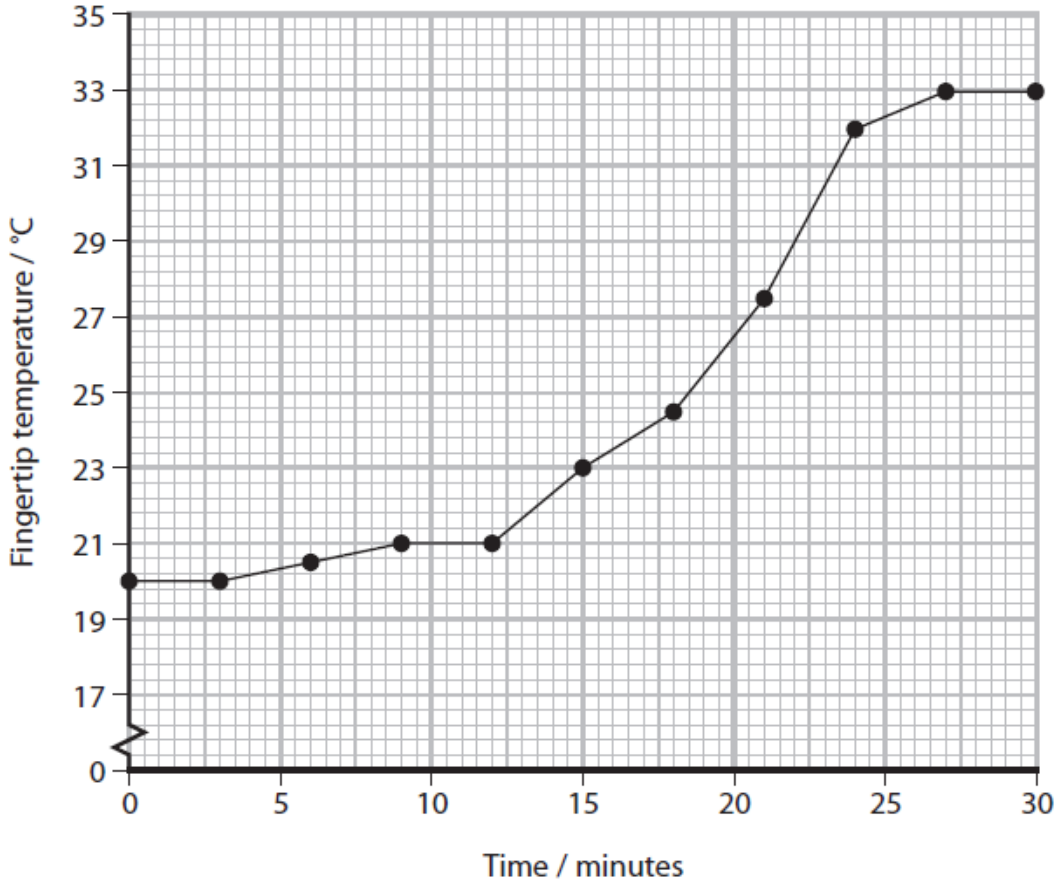


www.aa.com

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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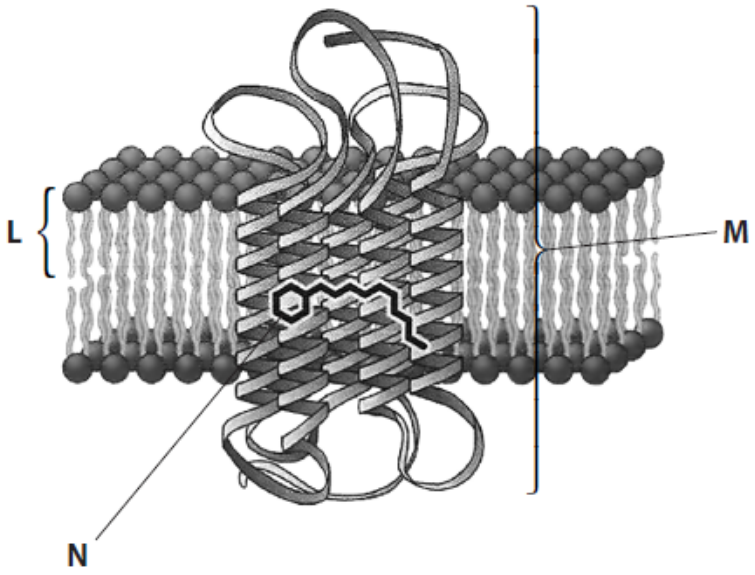
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(Total for question = 9 marks)

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.

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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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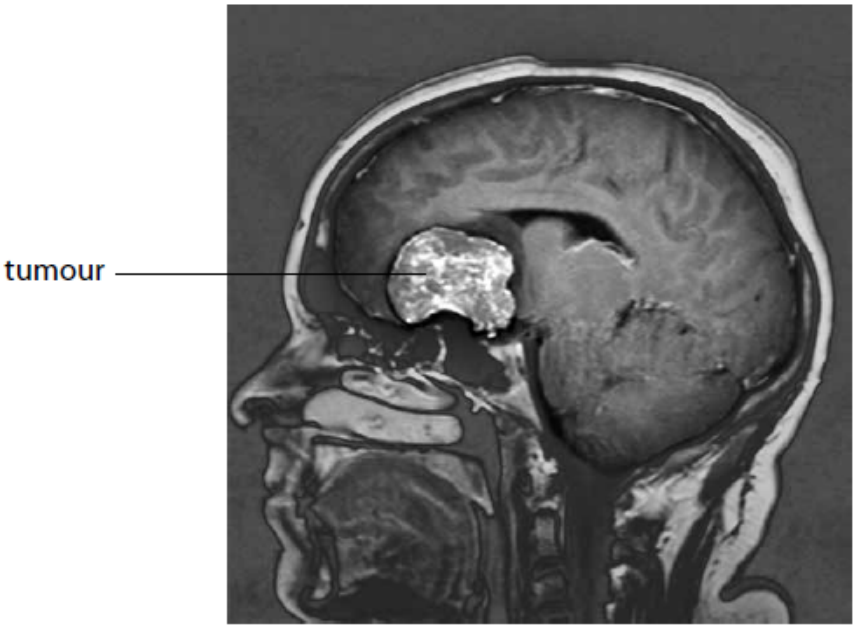
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(Total for question = 2 marks)

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 ×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 suchas 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.

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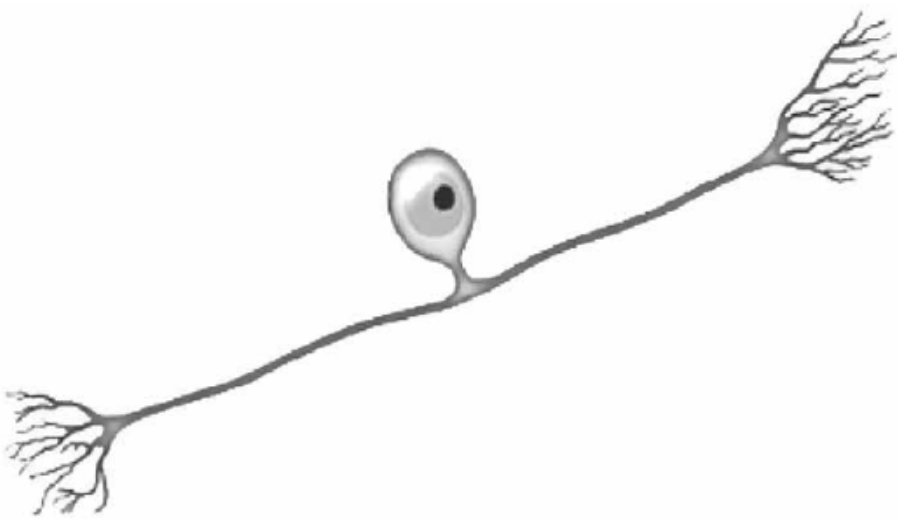
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(Total for question = 4 marks)

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 µm.

Conduction velocity / 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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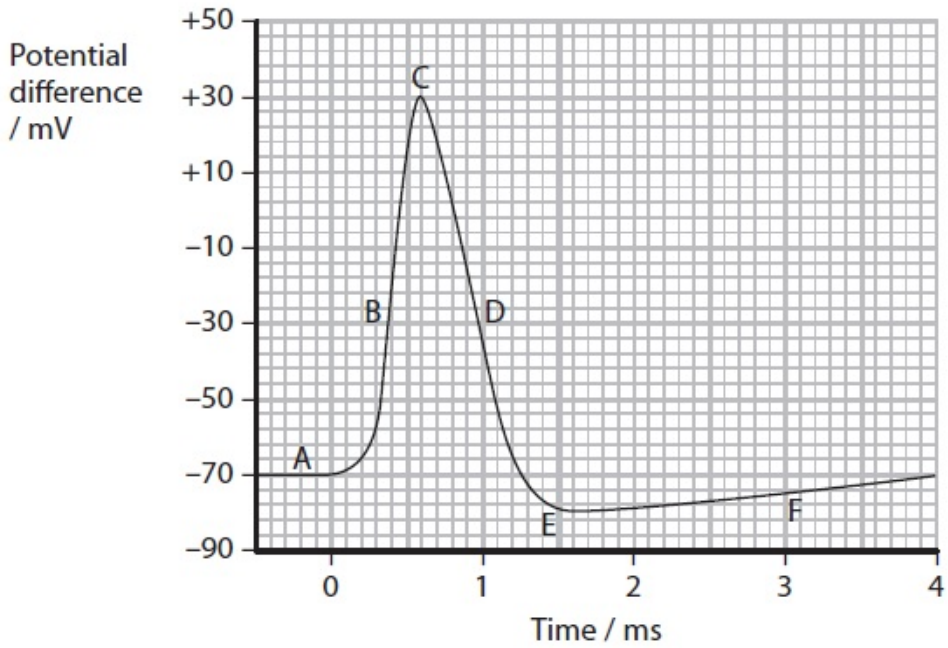
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(Total for question = 9 marks)

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	☒	☒	☒	☒	☒	☒
Stage when hyperpolarisation first occurs	☒	☒	☒	☒	☒	☒
Stage showing the resting potential	☒	☒	☒	☒	☒	☒

*(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.

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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.

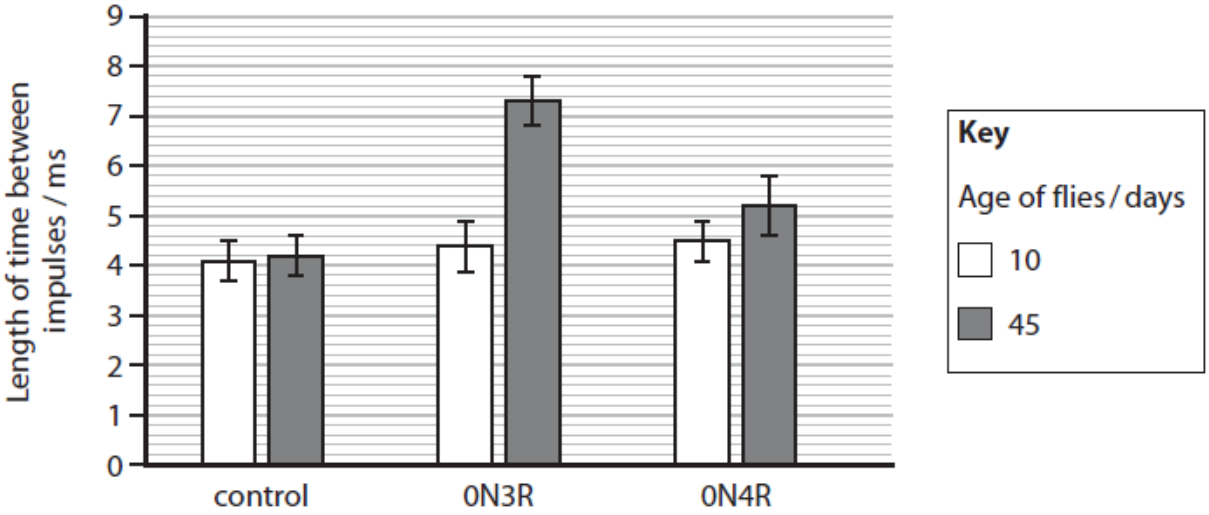
Scientists are studying the effect of these different TAU proteins in animal models.

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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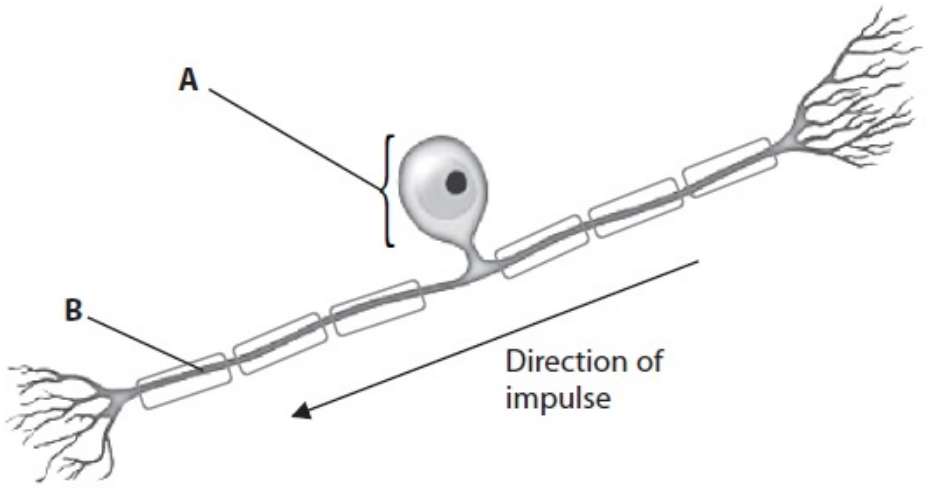
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(Total for question = 4 marks)

Q24. The diagram below shows a sensory neurone.



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

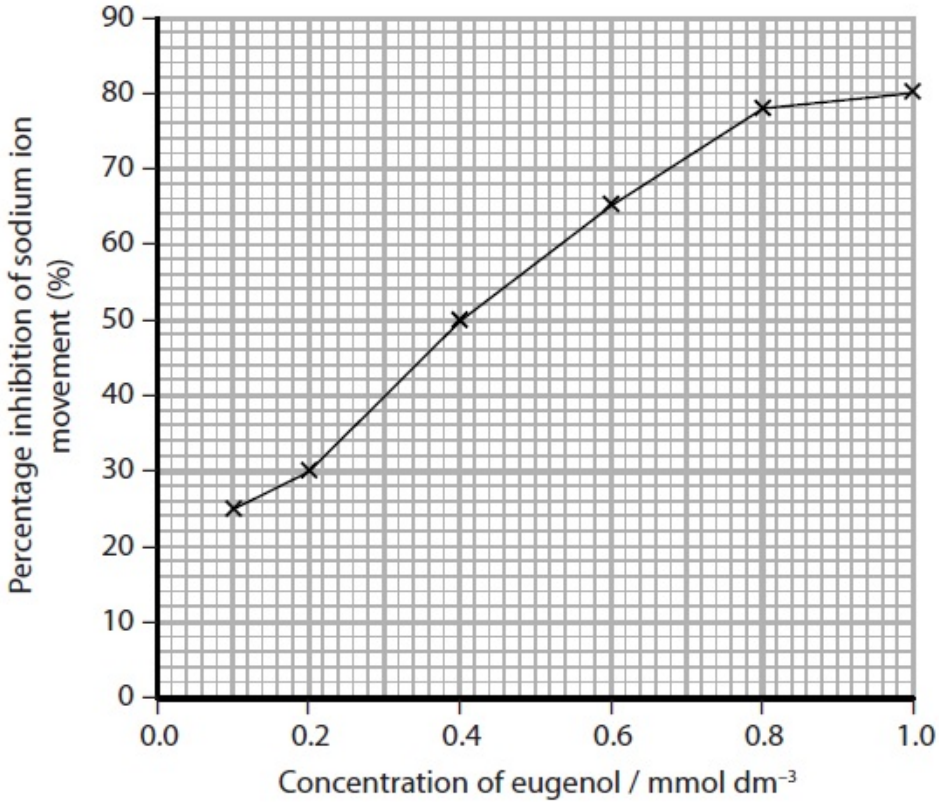
(2)

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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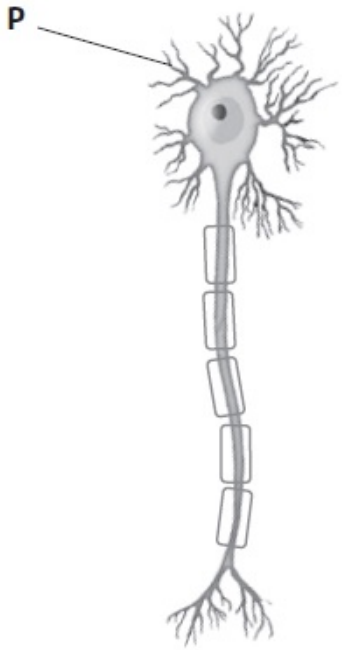
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(Total for Question = 10 marks)

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)

☒ A →

☒ B ↓

☒ C ←

☒ D ↑

(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 / mmol dm^{-3}	Percentage inhibition of sodium 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 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)

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	☐	☐	☐
Cell terminates at the effector	☐	☐	☐
Pre-synaptic membrane not found in the central nervous system	☐	☐	☐
Impulse stimulated by the receptor	☐	☐	☐

(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)

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(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.

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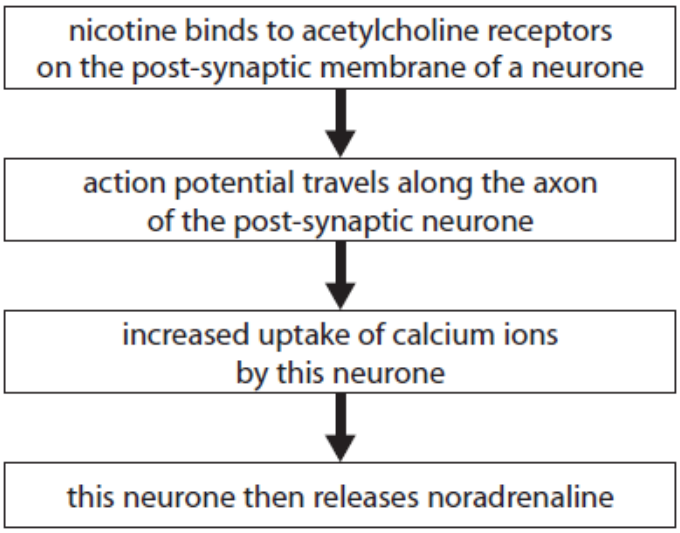
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(Total for question = 12 marks)

Q2.

Nicotine is a drug found in the smoke of cigarettes.

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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(d) Suggest a mechanism that could have been used to genetically modify cells from mice with cancer-causing genes (paragraph 13).

(2)

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*(e) Whilst naked mole rats are 'impervious to chemical pain' they do feel 'acute pain such as cuts and burns' (paragraph 31).

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

Explain how myelination increases the speed of transmission of nerve impulses in a sensory neurone.

(5)

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(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.

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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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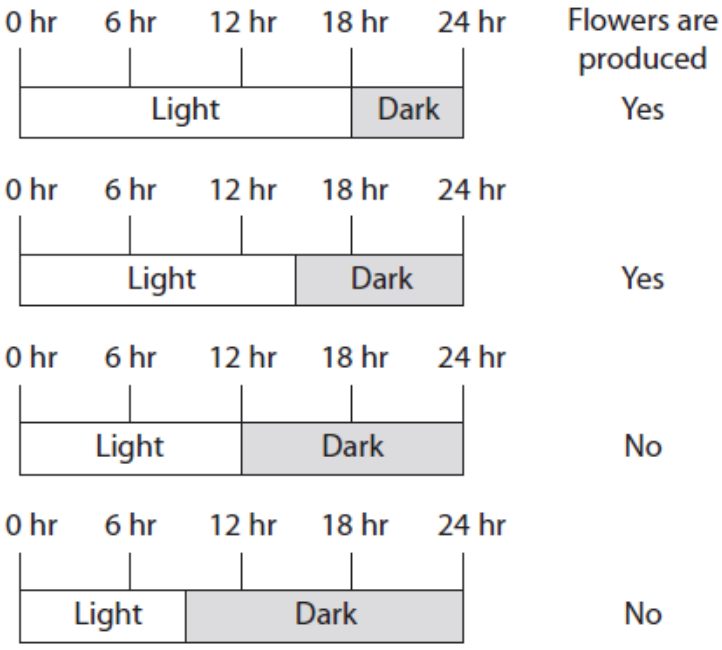
(Total for question = 2 marks)

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.



(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.

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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
☒ **A**	P_{FR} to P_R	slow
☒ **B**	P_{FR} to P_R	rapid
☒ **C**	P_R to P_{FR}	slow
☒ **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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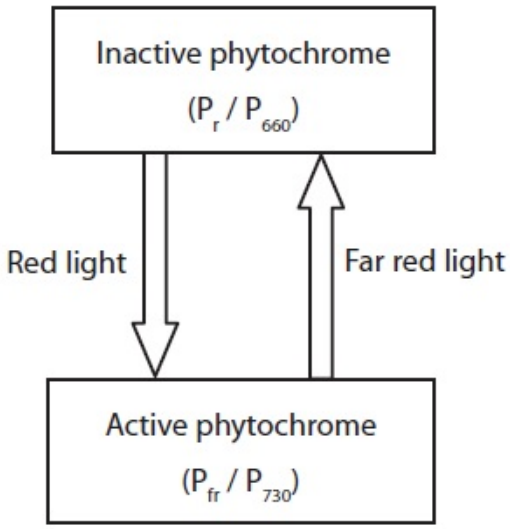
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(Total for question = 3 marks)

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 × 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.

(3)

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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.



© Johner 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.

(2)

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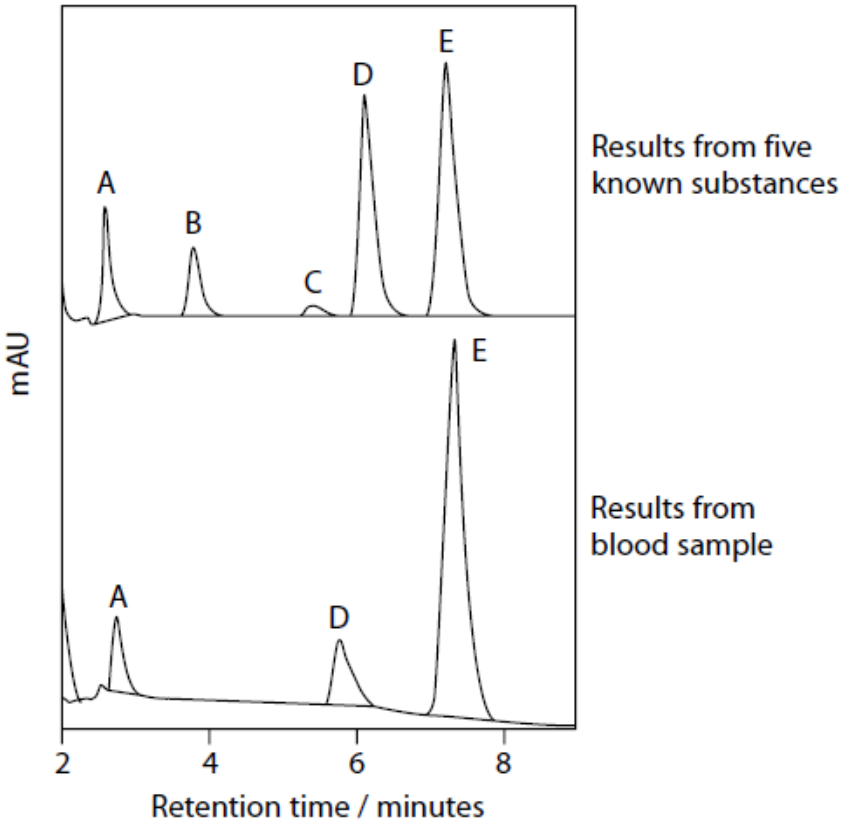
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(h) Gas chromatography (GC) can be used to detect athletes who have taken banned drugs (paragraph 48).

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.

(4)

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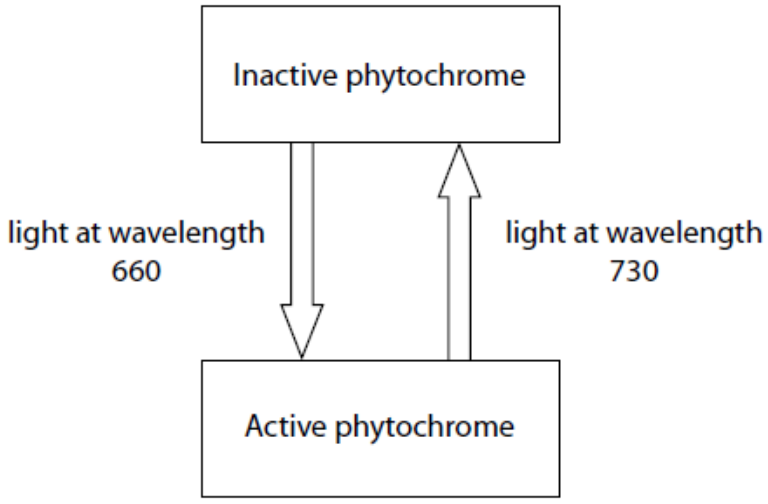
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(Total for question = 33 marks)

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
☒ **A**	yes	no	yes
☒ **B**	no	yes	no
☒ **C**	no	yes	yes
☒ **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)

Q14.

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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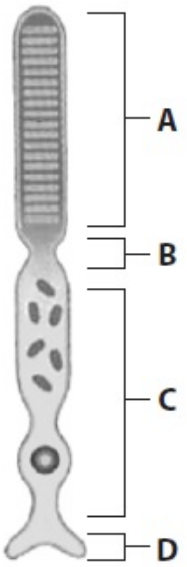
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(Total for question = 2 marks)

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	☐	☐	☐	☐
Containing the photosensitive pigment	☐	☐	☐	☐
Has a pre-synaptic membrane	☐	☐	☐	☐

(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.

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

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

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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.

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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.

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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.

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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.

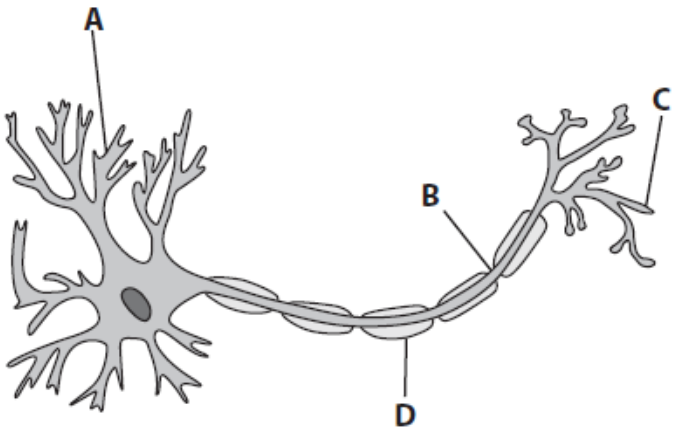
(i) The table below identifies two stages in the transmission of an impulse in a sensory neurone.

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

(2)

Stage	Voltage-gated K^+ channels open	Voltage-gated K^+ channels closed	Voltage-gated Na^+ 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.

(1)

☒ **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).

(6)

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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.

(2)

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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.

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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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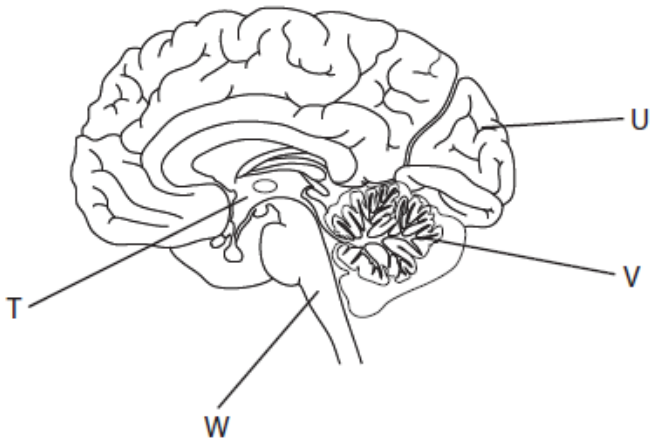
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(ii) The diagram shows a human brain.



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.

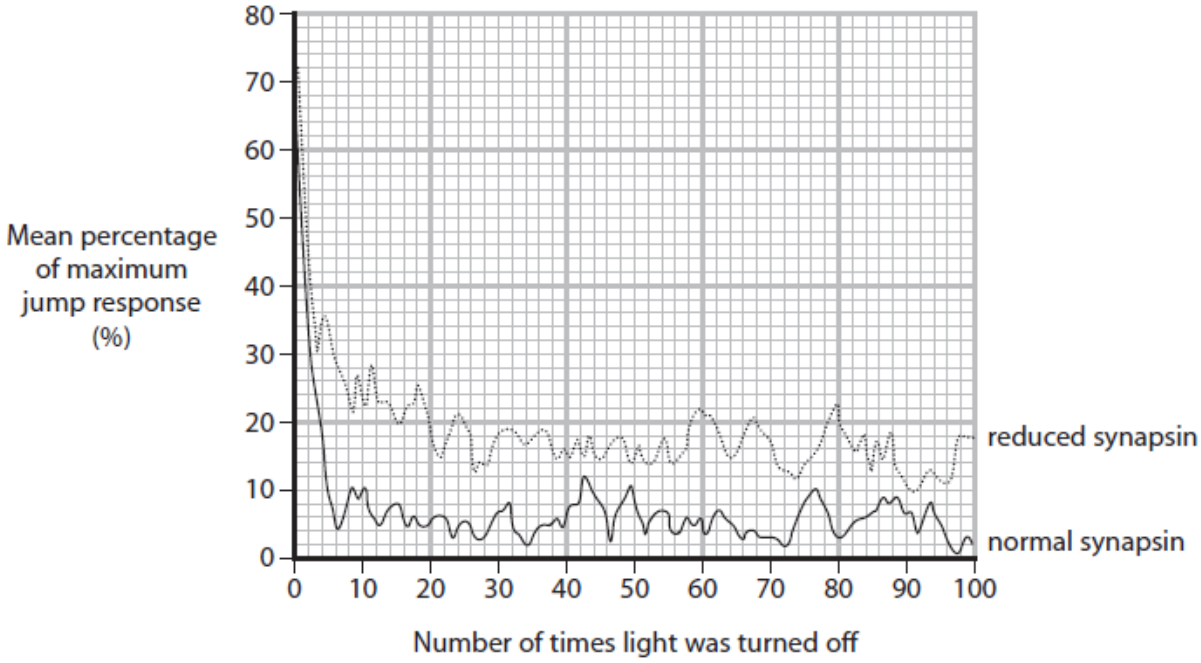
When the light is turned off the flies jump into the air and attempt to fly away.

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.

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

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(Total for question = 8 marks)

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.

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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 / ng cm^{-3}
0 (immediately after inhalation)	35.0 ± 9.3
30 (after inhalation)	24.1 ± 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 ..... ng cm^{-3} 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 / μm	
	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.

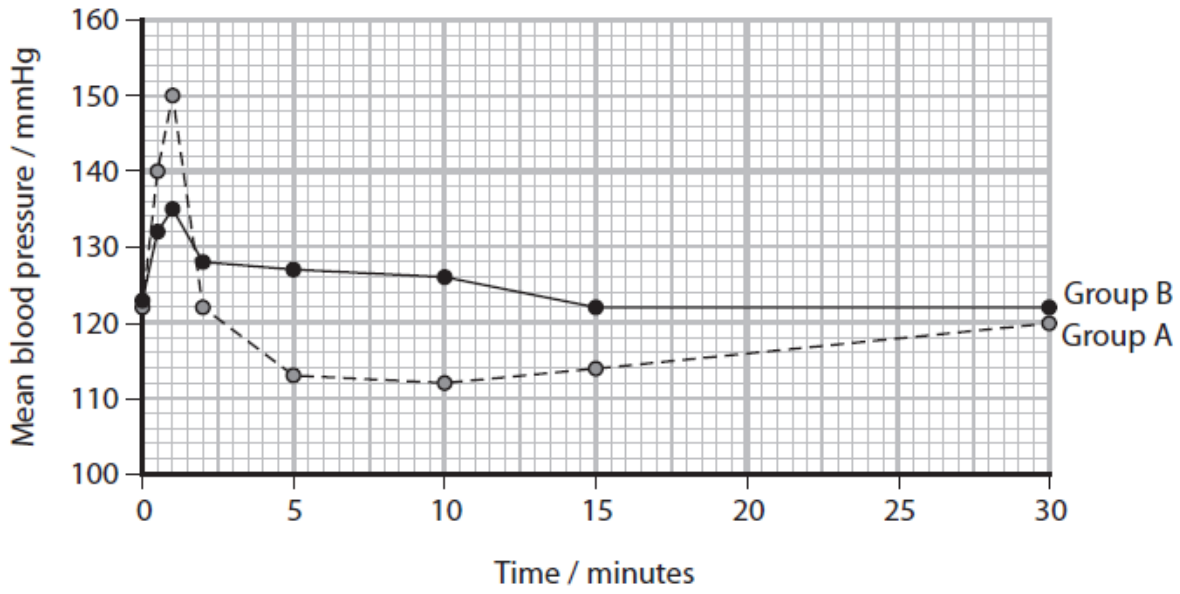
(2)

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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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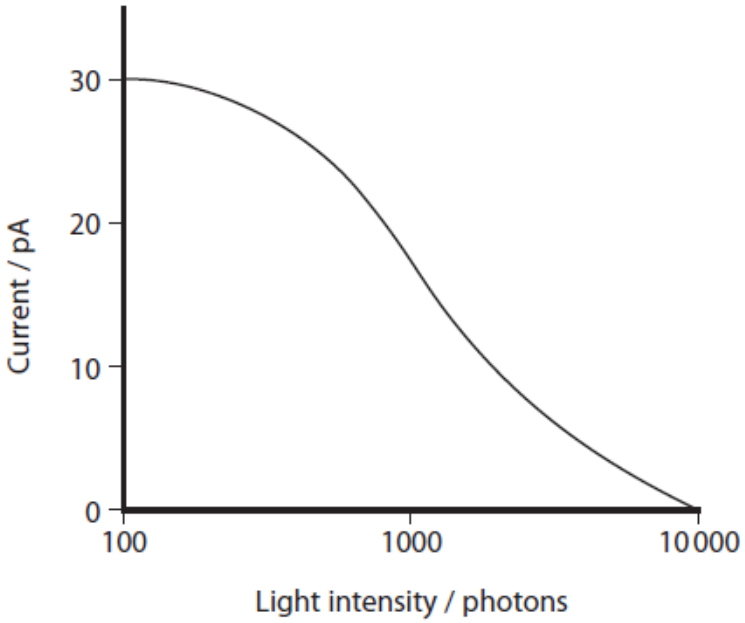
(Total for question = 10 marks)

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.

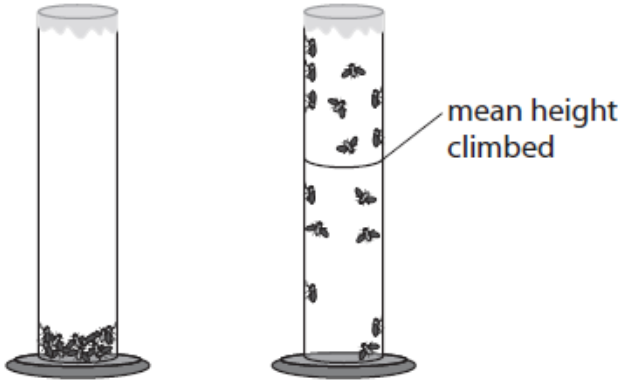
Scientists are studying the effect of these different TAU proteins in animal models.

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.

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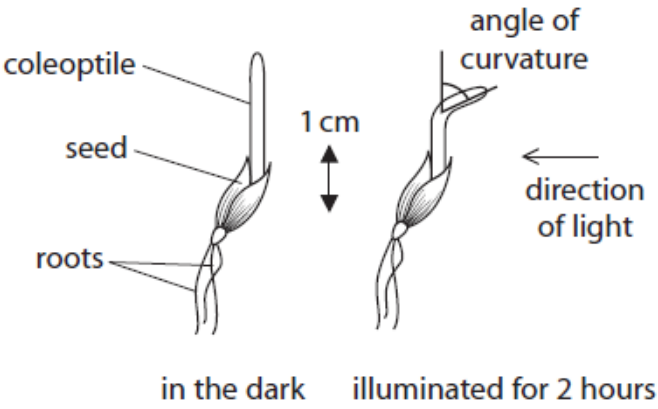
(Total for question = 3 marks)

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.



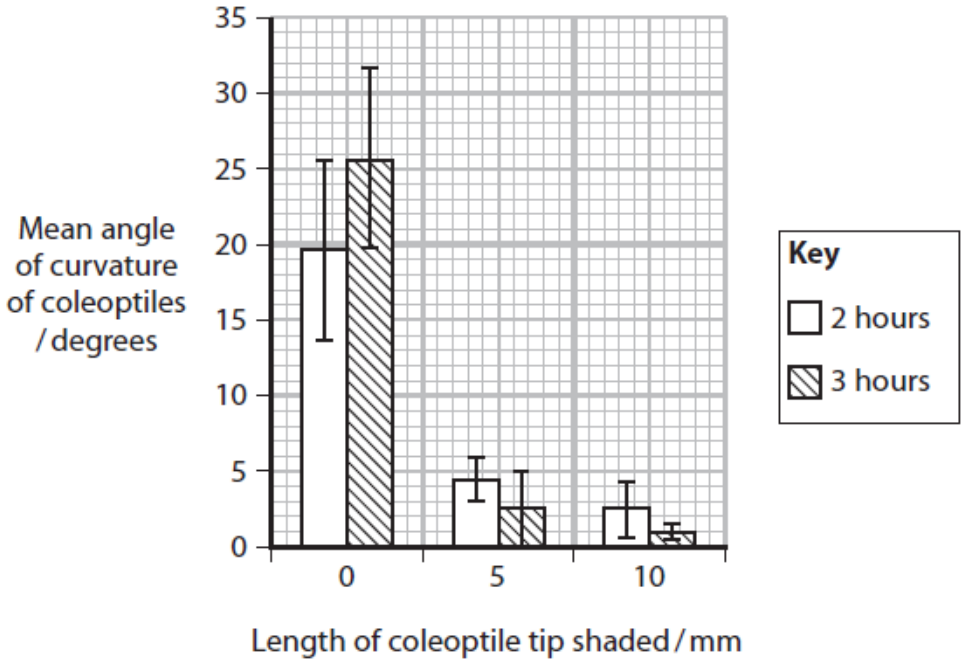
Oat seeds were germinated. When the coleoptiles were 2 cm long the seedlings were split into three groups.

- 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.

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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.

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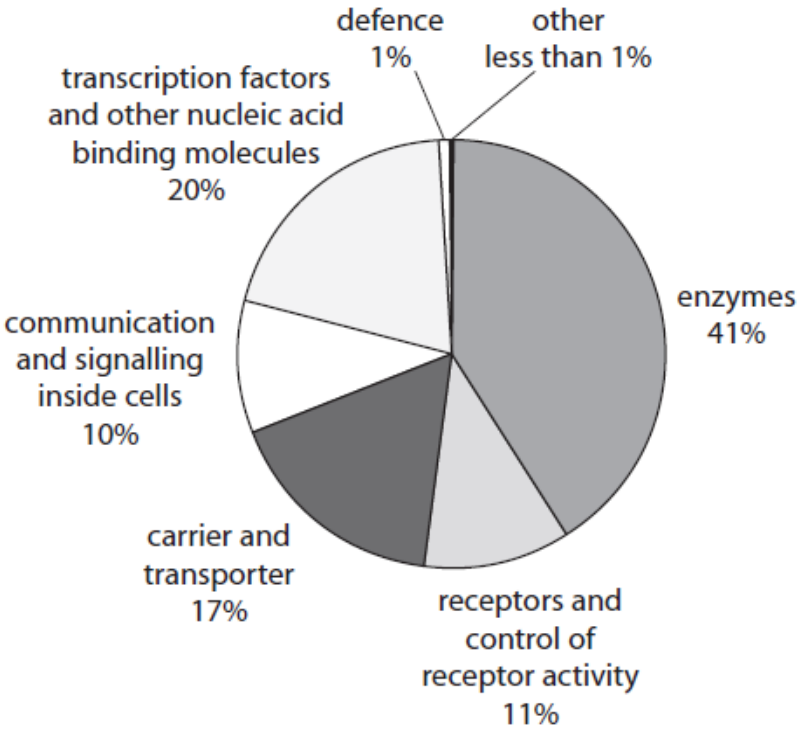
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(Total for question = 4 marks)

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.

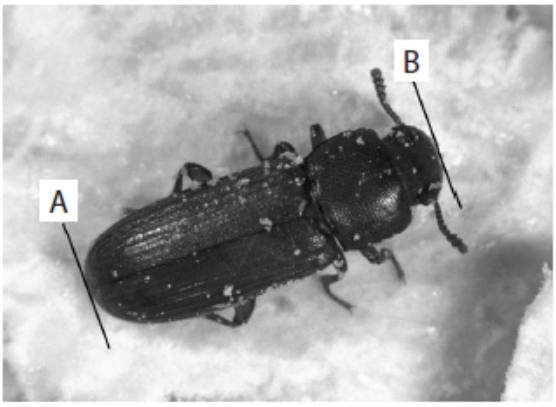
(9)

(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 ×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.

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(Total for question = 4 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.

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.

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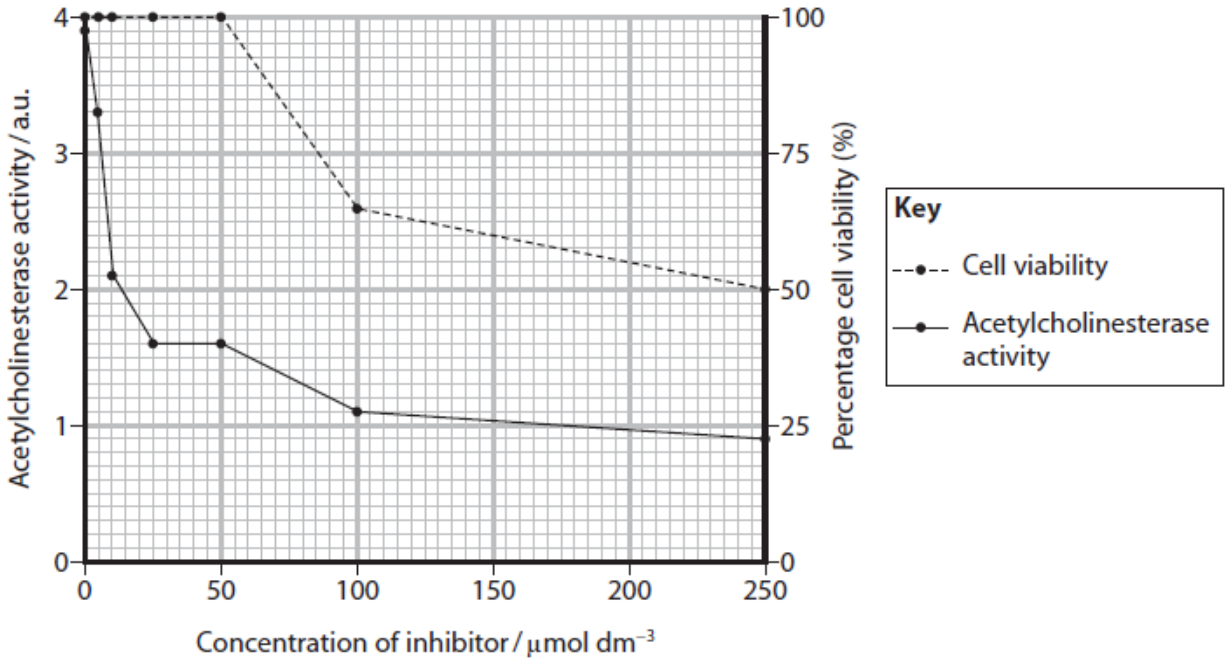
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(ii) Trials of a new inhibitor were carried out using tissue cultures.

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.

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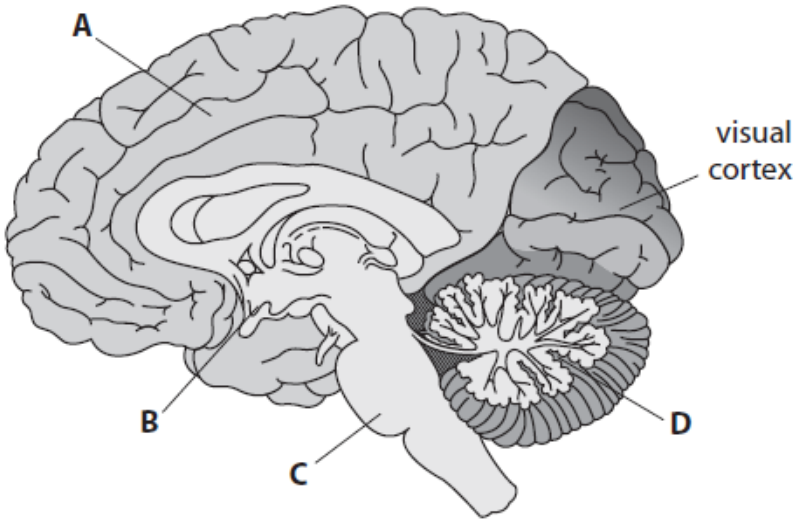
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(Total for question = 6 marks)

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.

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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.

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(ii) Explain why the use of CRISPR-Cas9 technology can be described as personalised medicine.

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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)