PEARSON EDEXCEL A-LEVEL BIOLOGY A · 9BN0

BIOLOGY



MARK SCHEME

TOPIC 8: GREY MATTER

SCORE	PERCENTAGE
/582	%

STEMUP

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Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to three of the following: • ocular dominance columns (develop in visual cortex) (1) • neurones form synapses with these { cells / columns } (1) • { stimuli / action potentials / impulses } along neurones required to strengthen connections (with cells of ocular dominance columns) • stimulation during the critical period is needed to form (effective) connections in the visual cortex	ALLOW columns of (target) cells ALLOW more synapses for stronger connections OR connections become weaker if stimuli not received	**(3)**

Q2.

Question Number	Answer	Additional Guidance	Mark
	In sensory neurone: 1. dendron longer; 2. dendron myelinated ; 3. axon shorter ; 4. {cell body / eq} {not at the end / towards the middle / to the side / eq } ; 5. reference to no {motor end plate / eq} ;	ALLOW converse for motor neurone 4. **ACCEPT** centron / nucleus for cell body	**(3)**

Q3.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following: • antagonistic (interaction) of muscles (1) • in the iris (1) • radial muscles contract and circular muscles relax (1)		**(3)** **Exp**

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following: • (DNA) ligase (joins the two genes) (1) • by joining phosphate to sugar / forming phosphodiester bonds (1) • by condensation reactions (1) • description of role of active site of enzyme (1)		**(3)**

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

Question Number	Answer	Additional guidance	Mark
(iii)	An explanation that makes reference to the following: • so that only bacteria with the antibiotic resistance gene survive (1) • therefore, these bacteria will also have the genefor spider silk (1)		**(2)**

Question Number	Answer	Additional guidance	Mark
(iv)	An answer that makes reference to two of the following: • IAA to cause cell elongation (1) • detail of how IAA affects plant cells (1) • to grow plants that produce spider silk (1)	ALLOW alters pH of cell wall / makes cellulose cellwall more plastic / effect on transcription ALLOW stimulates roots to grow	**(2)**

Question Number	Answer	Additional guidance	Mark
(v)	An answer that makes reference to the following: • mass per acre per year for goats (1) • correct calculation of difference in mass of spider silk produced (1) • correct percentage increase (1)	Example of calculation 10 x 12 = 120 (kg per acre per year)218-120 = 98 (kg per acre per year) 81.66 / 81.7 / 82 (%) Correct answer with no working gains fullmarks	**(3)**

Q5.

Question number	Answer	Additional guidance	Mark
(i)	A description that makes reference to two of the following points: • MDMA { stimulates release / prevents re-uptake / increases concentration } of serotonin (1) • blocking pre-synaptic receptors / binding to post synaptic receptors (1) • nerve pathways using serotonin are more likely to be stimulated / more action potentials produced (1)	ALLOW reference to dopamine instead of serotonin ALLOW more impulses generated	(2)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to two of the following points: • MDMA use results in depletion of serotonin (1) • post synaptic membrane becomes less responsive to serotonin / loss of receptors on post synaptic membrane (1) • serotonin levels affect mood / lack of serotonin associated with depression (1)	ALLOW dopamine instead of serotonin for all points	(2)

Q6.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	58- 45 = 13 (13÷58)×100 (1) = 22.4% (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • mass higher in A (compared with B) for both studies (1) • the difference is less in repeat study / mass lower in repeats (of both A and B (1)		**(2)**

Q7.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to four of the following points: • plants grown in pots containing same {soil / pH / minerals / water}as these factors can affect growth (1) • one group under lamp emitting red light and one group under a lamp emitting far red light / one group under lamp emitting red and far red light at same intensity and one group under lamp emitting far red light at higher intensity than red(1) • keep temperature the same in both as enzymes involved in growth (1) • reference to {several groups of pots / multiple plants} to ensure results are {reliable / suitable for valid statistical analysis} (1) • use {cloned / genetically identical} plants of same species as genes can affect growth (1)		**(4)**

Q8.

Question Number	Answer	Mark
(i)	• C -60 millivolts *The answer is not A as – 80 millivolts is the maximum hyperpolarisation* *The answer is not B as – 70 millivolts in the resting potential* *The answer is not D as + 40 millivolts is the action potential*	**(1)** **Comp**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • voltage gated sodium ion channels open and sodium ions {diffuse into /move in } from outside the cell (1) • (therefore causing an) increase in sodium ion concentration (1) • voltage gated potassium ion channels open and potassium ions {diffuse out / move out} from the inside (1) • (therefore causing an) decrease in potassium ion concentration at or after { 7 milliseconds / 40 mV } (1)	ALLOW sodium gates for voltage gated sodium ion channels ALLOW decrease in potassium ion concentration with repolarisation	(4) Exp

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to three of the following: • potassium ions (continue) leaving the {axon / cytoplasm} (1) • (therefore) preventing another depolarisation occurring / it is the refractory period (1) • allowing time for the neurone to reset (1) • so that nerve impulses travel in one direction only (1)	ALLOW voltage gated potassium ion channels remain open ALLOW prevents an action potential from being generated ALLOW time to return to resting potential	(3) Exp

Q9.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • the benefits of the research outweigh any harm done (1) • need to carry out experiments on animals with a well-developed CNS (1)	ALLOW CNS and spinal cord injuries are difficult to treat / CNS and spinal cord injuries have serious impact on people's lives / important research ALLOW experiments on tissues or invertebrates would not be sufficient IGNORE better than using humans / humans have more rights etc IGNORE have similar immune system / have less well developed nervous system	**(2)**

Q10.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following: Argument in favour • a utilitarianism – the overall benefits of the experiments are greater than any harm done (1) • welfare argument - animals can be used if they are treated well as far as possible (1) Argument against • rights argument - all animals have rights (not just humans) (1) • results may not be applicable to humans (1) • consent argument - animals are unable to give consent (as is required for human trials) (1)	e.g. animals can be used if their use is regulated e.g. it is not acceptable to keep animals in laboratory cages / not acceptable to cause pain suffering to mice	Expert (4)

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	A description that makes reference to the following: • utilitarian argument, better to test on animals than on humans (1) • the benefits to humans must outweigh harm done to other animals (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: • to determine safe dose (1) • to determine side effects (1) • to determine how the drug is metabolised (1)		**(2)**

Q12.

Question number	Answer
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. Indicative content: Benefits Described: • crops have increased yield due to pest control or resistance to disease • reduced need to use pesticides • crops can be grown in a wider range of conditions, e.g. harsh conditions, drought etc Discussed: • hybridisation could allow crop plants to have genes for tolerance to harsh conditions from genome D • crops have higher nutrient content, or produce a greater range of useful chemicals e.g. pharmaceutical products • genetic modification can be beneficial if crops are resistant to herbicides - crops can be sprayed with herbicide without { being harmed / causing reduction in yield } Risks Hybridisation: • hybridisation can lead to pest species which have ability to grow in wide range of conditions • hybridisation could allow genes for tolerance to harsh conditions from genome D to enter pest species GM: • genetic modification may result in genes entering pest species, making control difficult or into food chains • GM can introduce antibiotic resistant genes to other species Selective breeding • selective breeding reduces { genetic diversity / size of gene pool }, or causes genetic drift • leading to loss of useful alleles / reducing the ability of the crops to adapt to environmental change

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

Q13.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	pyruvate and { reduced coenzyme / reduced NAD }		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	A description that makes reference to the following: • Final electron acceptor		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(ii)	An explanation that makes reference to the following: • carbon monoxide binds to cytochrome oxidase (1) • prevents oxygen binding to the enzyme (1) • blocks the electron transport chain / prevents oxidation of reduced electron carriers (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	An explanation that makes reference to the following: • NO binds to cytochrome oxidase in endothelium (of blood vessels) (1) • diverts oxygen to smooth muscle cells (1) • contraction of muscle cells causes vasoconstriction in arterioles (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d)	An answer that makes reference to three of the following: • free radicals interact with transcription factors (1) • activation of gene for P53 (1) • production of mRNA from activated gene (1)		

Question Number	Acceptable Answer	Additional Guidance	Mark
	• translation of mRNA (1) resulting in synthesis of P53 on ribosomes		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(e)	A description that makes reference to three of the following: • inner membrane { is folded / has a larger surface area / has cristae } (1) • outer membrane is impermeable to H^+ ions (1) • only inner membrane contains { ETC (proteins) / ATP synthase / stalked particles} (1) • only inner membrane contains H^+ pump (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(f)	An answer that makes reference to the following: • myocardial infarction causes cell death in the heart (1) • due to lack of oxygenated blood reaching cardiac muscle cells (1) • NIR affects cytochrome oxidase involved in aerobic respiration (1) • diversion of oxygen to cardiac muscle cells would reduce death of these cells (1)		**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(g)(i)	A description that makes reference to the following: • restriction endonuclease enzyme (1) • extraction of gene that codes for light-sensitive protein (1) • use of a suitable vector (1) • insertion of gene into the { genome / DNA } in the nucleus of the neurone (1)		**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(g)(ii)	An explanation that makes reference to the following: • { depolarisation / action potential } occurs (1) • (nerve) impulse reaches { synapse / presynaptic membrane } (1) • calcium ion channels open causing calcium ions to enter presynaptic neurone (1) • vesicles containing neurotransmitter fuses with presynaptic membrane (1) • neurotransmitter released (1)		**(5)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(h)	An explanation that makes reference to three of the following: • fMRI detects changes in blood flow in the brain (1) • MRI signal reflects state of haemoglobin / magnetic fields repelled by oxygen rich blood / deoxygenated haemoglobin more magnetic than oxygenated haemoglobin (1) • allows areas of greater brain activity to be detected as an image created by magnetic resonance (1) • areas of the brain that are involved in an auditory memory task { were using more oxygen / had an increased flow of blood } (1)		**(3)**

Q14.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: • potential difference across axon changing (1) • due to increased permeability to sodium ions / (voltage gated) sodium channels open (1) • sodium ions { move into the axon / cause depolarisation } (1) • (followed by) an increased permeability to potassium ions / potassium channels open (1) • potassium ions { move out of the axon / cause repolarisation of the membrane } (1)	e.g. when depolarised from negative to positive or from -70mV to +40mV or repolarised from +40mV to -70mV	(4)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: • changing a base results in a change in the triplet code • this changes the codon(s) in the mRNA • resulting in a different { amino acid / amino acid sequence } (in the primary structure)	ALLOW deletion / substitution / insertion / frameshift. ALLOW illustration of change in triplet code e.g. ATT to ATG ALLOW introducing a stop codon / terminating translation	**(3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • sequence the genome of people with MPS1 • sequence the genome of a number of people without the condition • compare the base sequences to identify mutations found only in individuals with the condition	ALLOW comparison of base sequences of people with MPS1 and people without MPS1	**(3)**

Q16.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • no difference in action potential between individual with and individual without GBS • motor neurone conduction speed is reduced • due to { loss of myelin / demyelination } of the (motor) neurone • (and therefore) loss of saltatory conduction	IGNORE reference to sensory neurone ALLOW reference to loss of Schwann cells DO NOT ALLOW destroy ALLOW impulse cannot pass between the nodes of Ranvier	**(4)**

Q17.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • drugs not delivered to { other / healthy} tissues (1) • overall dosage needed is less (1)	ALLOW drug does not {affect / reach} other tissues, drug not delivered to the whole body ALLOW converse ALLOW {higher concentration / more of the drug} delivered to area where needed	**(2)**

Q18.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to the following: • plants respond to light / plants show phototropic responses (1) • (therefore) light must be excluded in order to study the effects of gravity (1) • (putting plants in the dark) therefore prevents light having an effect (1)	ALLOW plant shoots grow towards light ALLOW 'geotropism' for 'effects of gravity' ALLOW to control light	**(3)**

Question Number	Answer	Additional guidance	Mark
(ii)	• correct values selected from the graphs (1) • correct calculation of mean rate of curvature with units (1)	<u>Example of calculation</u> 58 and 9 49 ÷ 23 = 2.1 {degrees per day / ° day^{-1}} ALLOW 2.13 degrees per day Correct answer without working gains full marks Correct value without units gains 1 mark	**(2)**

Question Number	Answer	Additional guidance	Mark
(iii)	An answer the makes reference to two of the following: • do not have allele conferring ability to respond to gravity / only have alleles that confer a lack of response to gravity (1) • (so) do not produce {IAA / auxin} (1) • (therefore) lack of stimulation of cell elongation on side of stem facing downwards (1)	ALLOW cells present in the stem fail to detect gravity ALLOW there is no auxin present	**(2)**

Q19.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to the following: • sequencing the {genome / genes / DNA} of people with (and without) ASD (1) • identify (genes that have) {mutations / differences in sequence} (between ASD and non-ASD individuals) (1)	ALLOW compare genomics of people with and without ASD ALLOW DNA profiling of people with ASD	Expert (2)

Q20.

Question Number	Answer	Mark
	• Diagram C *The answer is not diagram A because the labelled regions do not match the descriptions* *The answer is not diagram B because the labelled regions do not match the descriptions* *The answer is not diagram D because the labelled regions do not match the descriptions*	**(1)** **comp**

Q21.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to the following: • due to more activity (1) • an increase in { oxygenated blood / blood flow } to this region (1) • fMRI signals { reflected / not absorbed } by oxygenated blood (1)	ALLOW increased aerobic respiration ALLOW oxyhaemoglobin or oxygen-rich blood for oxygenated blood ALLOW oxyhaemoglobin or oxygen-rich blood for oxygenated blood	**(3)** **Exp**

Question Number	Answer	Additional Guidance	Mark
(ii)	A description that makes reference to three of the following • (using both provides information on) function (PET) and structure (1) • PET scan shows areas that are {more (metabolically) active / dividing more } (1) • CT scan gives {location / size} (1) • each scan uses a different technique / techniques described (1)	ALLOW reference to 3D images (with PET and CT) e.g. CT uses X-rays and PET radioactively labelled metabolite such as glucose	(3) Exp

Q22.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(i)	A description that makes reference to the following: • gene is a length of DNA that codes for a { polypeptide / protein } (1) • genome is a complete set of { DNA / introns and exons } (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(ii)	ligase / integrase		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(iii)	plasmid / virus		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(iv)	A description that makes reference to the following: • transcription of DNA to mRNA (1) • { translation of mRNA / protein synthesis } (1) on ribosomes		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to the following: • no prothrombin activated so thrombin not produced (1) • thrombin needed to convert fibrinogen to fibrin (1) • fibrin needed to trap { platelets / blood cells } to form the (blood) clot (1)		**(3)**

Q23.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	An explanation that makes reference to the following: • fraternal twins risk is lower (1) • because fewer alleles in common (1)	Allow converse	**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	An explanation that makes reference to the following: • Identical twins being raised apart allows environmental factors to be investigated separately from genetic factors (1) • therefore may be able to determine relative amount of risk due to genetic variation / relative amount of risk due to environment (1)		**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	An answer that makes reference to the following: • twins have more in common than shared genetics / shared uterine environment (1) • twins may be raised in similar environments(1)	Ignore reference to sample size	**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	An explanation that makes reference to the following: • Parkinson's symptoms arise due to low dopamine levels (1) • transmission of nerve impulses disrupted causing lack of control of {muscle movements / tremors} (1) • schizophrenia drugs lower {neurotransmitter / dopamine} levels (1) Plus two from: • therefore less dopamine in synaptic / knob secreted into cleft / diffuses across cleft (1) • therefore less dopamine available to bind to receptors (1) • therefore no/little change in membrane structure / permeability of post– synaptic cell (1) • therefore fewer sodium ions enter postsynaptic cell (1) • therefore less depolarisation of postsynaptic cell (1)		**(5)**

Q24.

Question Number	Answer	Mark
(a)	1. reference to {restriction enzyme / endonuclease} ; 2. to cut gene out of animal DNA ; 3. idea of amplification using DNA polymerase (in PCR) ; 4. (enzymes) open plasmid ; 5. (same endonuclease) to produce 'sticky ends' /description / at selected base sequence ; 6. H bonds formed between bases at 'sticky ends' ; 7. ligase ; 8. to join gene to plasmid / eq ; 9. reference to {phosphodiester / eq} bond ;	**(5)**

Question Number	Answer	Mark
(b)	1. (small) {circle /eq} of DNA ; 2. containing bacterial (survival) genes and {protein / animal} gene ; 3. marker gene / description given ;	**(2)**

Question Number	Answer	Mark
(c)	1. idea of easier to manage growth e.g. do not need sterile conditions ; 2. idea that it is safer (than bacteria) ; 3. idea of more protein can be made /eq ; 4. bacteria may not have correct amino acids to make protein / eq ; 5. idea that it could produce edible drugs ; 6. idea that plants have introns/bacteria do not so gene does not need modifying ; 7. idea that it is cheaper ;	**(2)**

Question Number	Answer	Mark
(d)	1. idea of gene transfer to other {species / eq} ; 2. idea of consequence of transfer e.g. resistance to pesticide / antibiotics, superweeds ; 3. idea of possible harmful effects from genes e.g. biochemical changes to substances that could act as allergens, long term effects of consuming ; 4. idea that benefit focused on developed countries / converse ; 5. idea of risk related to use of viral vectors ; 6. idea of effect on organic farmers ;	**(2)**

Q25.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: • all the {DNA / exons and introns} **(1)**	DO NOT ALLOW 'all the genes in the DNA' / 'all the DNA in the genes'	**(1)**

Mark Scheme

Q1.

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

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

Q2.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to four of the following: • (repeated stimulus) decreases {sensitivity / permeability} of pre-synaptic membrane / calcium channels not opening **(1)** • so {fewer / no} Ca^{2+} ions move into pre-synaptic neurone **(1)** • so {fewer / no} vesicles {move towards / fuse with} (pre-synaptic) membrane **(1)** • so {less / no} neurotransmitter {released / can diffuse across gap} **(1)** • {action potential / depolarisation} less likely to occur in post-synaptic neurone **(1)**	ALLOW calcium channels less or not responsive	**(4)**

Q3.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • allows an animal (to learn) to ignore (repetitive) non-threatening stimuli (1) • therefore allowing it to focus on (potentially) more relevant stimuli (1)	ALLOW therefore allowing it to conserve {energy / resources} ALLOW converse – such as if animals did not habituate they would waste energy on unimportant stimuli	Expert (2)

Q4.

Question Number	Answer	Additional guidance	Mark
(a)	1. reference to phytochrome ; 2. idea that day length is the environmental cue ; 3. reference to critical period / photoperiod ; 4. this is more than 12 hours light / less than 12 hours darkness / eq ; 5. idea that different wavelengths of light are involved OR reference to inter-conversion of phytochromes e.g. because light supplies red light which converts P_R converted to P_{FR} ; 6. reference to florigen ;		**(3)**

Question Number	Answer	Additional guidance	Mark
(b)(i)	Both 1. chemicals ; 2. produced in cells / eq ; 3. idea that they move away from site of production ; 4. effect may be distant from production site / eq ; 5. long-term / permanent effect / example quoted / eq ; 6. involved in gene activation /eq ;	5. ACCEPT both can control growth 6. ACCEPT: Both can have an effect on gene inhibition	(3)

Question Number	Answer	Additional guidance	Mark
(b)(ii)	1. idea that weeds affected because e.g. more sensitive, take up more ; 2. idea that (auxin / IAA) causes cell elongation ;		(2)

Q5.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • {IAA/auxin} is a (plant) hormone (1) • (investigation showed) cells grew longer with IAA / IAA stimulates cell elongation (1) • {light sensing / IAA producing} cells are in the tip (of the coleoptile) (1) • (results show) cell elongation happened in cells below the (shoot) tip (1) • the response to IAA is (relatively) {slow / prolonged} (1)	ALLOW IAA caused cell growth / increases cell length ALLOW cells that respond to IAA are in a different part of the coleoptile to the light sensing structures for MP 3 and 4	Expert (3)

Q6.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: • cytokine can bind to receptor on synaptic membrane (1) • effect on an ion channel (1) • therefore affecting the movement of ions across the membrane (1) • affecting the depolarisation of the membrane (1) • therefore affecting action potentials (in the neural circuit) (1)	ALLOW inhibitory or stimulatory effects ALLOW binds to acetylcholinesterase e.g. opens chloride ion channel ALLOW other described effects on membrane e.g. chloride ions moving in or potassium ions moving out e.g. threshold potential is not reached	**(4)**

Q7.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to the following: • use of {MRI / CT / PET} scans (1) • before treatment and after treatment (1)	ALLOW ultrasound scans / clinical investigation ALLOW regular scans / scans at stated frequency / over course of treatment	Expert (2)

Q8.

Question Number	**Answer**	**Additional Guidance**	**Mark**
	An explanation that makes reference to four of the following: • IAA diffuses from the tip of the coleoptile (1) • (therefore) can be taken up by cells in zone of elongation (1) • which causes cells to elongate (1) • details of action in zone of elongation (1) • (therefore) causes the coleoptile to { grow towards the light / increase in height } (1)	e.g. leads to lowering of the pH in the cellulose cell wall ALLOW: positive phototropism IGNORE: bend for growth	**(4)**

Q9.

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

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

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to three of the following: • { form synapses / connections } with other neurones (1) • { integrate / receive } impulses from other neurones (1) • involved in summation • { propagate a signal / initiate an action potential } to the {cell body / axon}		**(3)**

Q10.

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

Question Number	Answer	Mark
(ii)	D ;	**(1)**

Q11.

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

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

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

Q12.

Question number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Reference to role of ions in • nerve conduction • release of neurotransmitters • muscle contraction Mention of • passive diffusion through ion channels • active transport against concentration gradients Examples of ion transport • active transport – sodium potassium pump • hydrogen ions in chemiosmosis • calcium channels in pre-synaptic knob • sodium and potassium channels in neurones Idea that ions moving down a concentration gradient can do work • ATP synthase in chemiosmosis • cotransporters Ion channels in disease • chloride channels in cystic fibrosis • credit any other sensible suggestions • Ideas around control • lots of different genes/proteins involved in transporting ions across membranes • specificity of channels for particular ions • control of opening and closing of different channels	**(9)**

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

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

Q13.

Question number	Answer
* (i)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content from table: • stimulated at just one point (V or W) – response lost after repeated stimulation • if the repeated stimulation is alternated between two points (V and W) the worm still responds by contracting its muscles / no habituation when stimuli alternated between different locations • different nerves / neurones / stimulated (by V and W) from diagrams: • there is a response at X every time the neurone is stimulated • { repeated stimulation / after three stimuli } there is no longer an impulse recorded at Y • electrode X is close to where the stimulus is applied and it detects an impulse each time • electrode Y is further from where the stimulus is applied • there is a synapse between the stimulus and the neurone monitored at Y Knowledge and understanding of habituation: • after repeated stimulation the impulse cannot cross the synapse • lack of neurotransmitter / not enough time to produce more neurotransmitter • calcium ion channels not opening when impulse arrives at the synapse • threshold not reached on the post-synaptic neurone and no action potential produced

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

Question number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following points: • description of suitable range of (at least five) frequencies (1) • a method for making application of stimuli consistent / control of recovery time between tests (1) • a method for checking for habituation in earthworms (1) • repeats with other earthworms of same { species / size } (1)	ALLOW range of five different frequencies above and below 20 per minute e.g. (touch with a cotton bud) to same place each time e.g. give 2 minutes between each test e.g. observing for no response to touch / finding no change in length of earthworm (Maximum of 2 marks if investigation described in context of snails)	(4)

Q14.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to two of the following: • {immunise / infect} animals at different times during early development (1) • investigate animals later in life for { effects on learning / the development of neurological conditions } (1)	 ALLOW compare animals with intact and with deficient (innate) immune systems ALLOW test animals' senses at different stages in development	**(2)**

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to two of the following: • time is required for heat to warm the blood (1) • because of the layer of insulation in the skin (1) • because it takes time for the warm blood to circulate (1)	 ALLOW it takes time for warm blood to reach the fingertip	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• maximum difference in temperature divided by time (1) • correct answer with units (1)	Example of calculation (32.0 - 27.5) ÷ 3 1.5 °C min^{-1} OR 1.5 °C per minute OR 1.5 °C / minute ALLOW 32.0 – 27.4 to give 1.53 for 2 marks Correct answer no working with units gains full marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to five of the following: • thermoreceptors detect increase in temperature (1) • description of role of hypothalamus in heat loss mechanism (1) • (therefore more) impulses are sent along the sympathetic { nerves / nervous system } (1) • which leads to constriction of shunt vessels (1) • therefore causing vasodilation (of arterioles) (1) • so more warm blood flows near the skin surface (1)	e.g. thermoreceptors in the hypothalamus detect temperature increase OR reference to role of heat loss centre / thermoregulatory centre in co-ordinating mechanisms of heat loss ALLOW so more warm blood in capillaries ALLOW radiation of heat energy from the skin	**(5)**

Q16.

Question Number	Answer	Additional Guidance	Mark
(a)	C (phospholipid)		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	rhodopsin		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(ii)	(cis) retinal		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	A description that makes reference to the following: • opsin released causing sodium ion channels to be blocked (1) • which causes hyperpolarisation in the rod cell (1) • causing action potential in bipolar cell (results in action potential in the optic nerve) (1)		**(3)**

Q17.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to two of the following points: • serotonin is a neurotransmitter / there will be less neurotransmitter (1) • (less serotonin) results in fewer depolarisations of post synaptic membranes (1) • threshold not achieved / less chance of action potential being produced (in post-synaptic neurone) (1)	ALLOW no serotonin or no neurotransmitter ALLOW no depolarisations ALLOW no action potential produced	(2)

Q18.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	B		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to three of the following: • MRI gives better resolution (1) • therefore more detail can be seen (1) • no use of X–rays (1) • therefore {safer / less risk of mutation / eq} (1) • therefore can be used more often (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	An explanation that makes reference to the following: • increased neural activity of {cerebellum / cerebrum} (1) • more oxygen needed so increase in {blood flow / oxyhaemoglobin} (1) • less {radio wave / signal} absorbed (1)		**(3)**

Q19.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: • extract mRNA for one form of the (tau protein) (1) • copy mRNA into DNA (1) • use restriction enzymes {to create sticky ends) / cut theDNA and a vector} (1) • {ligate / insert / integrate} the TAU DNA into the vector(DNA) (1) • introduce vector into {fertilised egg / embryonic stem /zygote / cells / neural cell stem cells} (1)	IGNORE cut / remove TAU gene from a humanALLOW synthesis DNA sequence for one form e.g. use code specific for one of the tau proteins ALLOW insert gene into fertilised egg cell /embryonic stem cell ALLOW egg cell fertilised after inserting gene	Choose an item. (4)

Q20.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• Idea that {cell body / centron} in middle / dendrites at both ends (1)		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to five of the following: • reference to Schwann cells covering the axon in myelinated neurone (1) • {myelin/Schwann cells} provide insulation (1) • {action potential/depolarisation} at nodes of Ranvier (1) • local currents occur over a longer distance (1) • reference to saltatory conduction (1) • impulse jumps from node to node (1)		**(5)**

Q21.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	1. identical twins (agreement) is greater / eq ; 2. credit correct manipulation of the data e. g. {41% more / 2.4x as much / 141% higher / eq} agreement than non-identical twins ; 3. idea that alleles are involved ; 4. idea that non-identical have genetic differences ; 5. idea that because less than 100% then some other factor is involved ;	ACCEPT converse where appropriate 2. ACCEPT 41% difference 3. ACCEPT gene alternatives 4. ACCEPT identical twins are genetically the same	**(4)**

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

Question Number	Answer	Additional Guidance	Mark
(b)	1. idea that active areas have more {oxygen / oxygenated blood} ; 2. active areas involved in face recognition will be identified / eq ; 3. idea of level of brain activity between identical twins and non identical twins is compared ; 4. to offer supportive evidence / improve validity of study ; 5. idea that fMRI shows brain activity in real time ; 6. idea of high resolution ; 7. comment on safety / eq ;	3. ACCEPT idea of {areas more active / more oxygenated blood flowing to areas} in identical twins compared with non-identical twins 3. ACCEPT idea of {more / eq} areas showing activity in common in identical twins than non-identical 7. ACCEPT fMRI does not use X rays	**(4)**

Q22.

Question Number	Answer	Mark
(a)(i)	100 (mV) ;	**(1)**

Question Number	Answer	Mark
(a)(ii)		**(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					☒	
Site showing the resting potential	☒					

Question Number	Answer	Mark
***(b)**	QWC – Spelling of technical terms (*shown in italics*) must be correct and the answer must be organised in a logical sequence 1. diffuses across {gap /eq} ; 2. binds to (receptors on) post-synaptic membrane / eq ; 3. idea of gated-channels opening or Na^+ travels through post-synaptic membrane ; 4. causing a depolarisation / eq ; 5. (if sufficient present) an action potential is set up in {post-synaptic membrane/adjacent cell / eq} ; 6. details such as temporal or spatial summation ; 7. idea that allows coordination / one way flow of information ; 8. idea that it allows integration in post-synaptic cell ; 9. neurotransmitter broken down (by enzyme) / eq ; 10. so that do not get {prolonged /eq} action potential in post-synaptic membrane / make receptors available again ; 11. credit reference to fate of products e.g. reabsorbed through pre-synaptic membrane OR to be re-synthesised into neurotransmitter substance ;	**(5)**

Q23.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • frequency is {the same / similar} for all flies at 10 days (1) • for older flies with {0N4R the error bars overlap with thecontrol (1) • therefore 0N4R has {no / little} effect on the frequency ofimpulses (1) • for older flies 0N3R the error bars do not overlap withthe control } (1) • therefore 0N3R decreases the frequency of impulses (1)	ALLOW length of time between impulses ALLOW frequency decreases from 220 to 190impulses per second ALLOW length of time between impulses IGNORE unqualified length of time / increase ALLOW frequency decreased from 227 to 137impulses per second ALLOW more significant / greatest effect ALLOW length of time between impulses IGNORE unqualified length of time / increase ALLOW effect was greater in older flies if MP2 to 5not awarded	Choose an item. (4)

Q24.

Question Number	Answer	Additional guidance	Mark
(a)	**A** - cell body ; **B** - axon ;		**(2)**

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

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

Q25.

Question Number	Answer	Additional Comments	Mark
(a) (i)	(terminal) dendrite ;		(1)

Question Number	Answer	Additional Comments	Mark
(a) (ii)	B ;		(1)

Question Number	Answer	Additional Comments	Mark
(b) (i)	1. Increasing eugenol concentration increase percentage inhibition / positive correlation ; 2. Description of non linear correlation ; 3. Credit correct manipulation of the data e.g. 0.8 mmol dm^{-3} increase causes percentage inhibition to increase by {x2.7 / eq} ;	**2. Ignore** references to rate or speed **Accept** greatest increase is between 0.2 and 0.4	(2)

Question Number	Answer	Additional Comments	Mark
(b) (ii)	Correct answer gains 2 marks 72.5 / 73.0 / 75 (%) ; ;	**Accept** for 1 mark (65 + 80) ÷ 2 or 145 ÷ 2 if answer incorrect	(2)

Question Number	Answer	Additional Comments	Mark
* (c)	QWC – Spelling of technical terms (shown in italics) must be correct and the answer must be organised in a logical sequence 1. higher concentration of Na^+ outside of neurone / eq ; 2. sodium ions move in causing a depolarisation / eq ; 3. eugenol may affect { Na^+ / voltage-dependent} gates / eq ; 4. eugenol reduces influx of Na^+ / eq ; 5. (so) depolarisation less likely to occur / eq ; 6. no impulse transmitted along neurone / eq ; 7. idea of no transmission to next neurone ; 8. idea of pain not being sensed as impulse stopped before entering CNS ;	**QWC emphasis is logical sequencing in the context of how eugenol affects the movement** **6. Accept** no action potential **7. Accept** no release of neurotransmitter	(6)

Mark Scheme

Q1.

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

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

Question Number	Answer	Additional guidance	Mark
(b)(ii)	1. supplies energy to allow opsin and retinal to combine ; 2. to (re)form rhodopsin ; 3. use in the transport of ions e.g. to allow Na^+ to be pumped out of cell ;		(2)

Question Number	Answer	Additional guidance	Mark
(b)(iii)	1. reference to actin and myosin interacting ; 2. ATP binds to myosin head causing {bond / cross-bridge / eq} between actin and myosin to break / eq ; 3. ATP {breaks / hydrolyses} into ADP and P_i {releasing energy that is stored in myosin head / causing myosin head to reset / eq} ; 4. myosin head binds to actin / {bond / cross-bridge forms} between actin and myosin / eq ; 5. P_i is released from myosin head / eq ; 6. energy in myosin head causes it to move / eq ; 7. idea that actin slides along ; 8. ADP is released at this time / eq ; 9. role of ATP in transport of calcium ions back into sarcoplasmic reticulum / eq ;		**(5)**

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three of the following: • nicotine similar in shape to acetylcholine (1) • increases permeability of membrane to sodium ions / changes shape of { receptors / channel proteins } (1) • nicotine causes the depolarisation of the post-synaptic membrane (1) • depolarisation reaches threshold level (1)	ALLOW { sodium ion / Na^+ } channels open ALLOW sodium ions { diffuse / move down concentration gradient } into the neurone	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • (calcium ions cause) vesicles (containing noradrenaline) to fuse with { cell (surface) membrane / presynaptic membrane } (1)	ALLOW (calcium ions cause) vesicles to release noradrenaline through exocytosis	(1)

Q3.

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

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

Question Number	Answer	Additional Comments	Mark
(c) (i)	Idea that body temperature of animal mimics the ambient temperature ;	**Accept** body temp follows environmental temperature	(1)

Question Number	Answer	Additional Comments	Mark
(c) (ii)	1. Lack of insulating layer: Idea that does not impede transfer of heat energy / allows exchange of heat energy more easily ; 2. A marked reduction in sweat glands: Idea that they do not need to cool down OR less water lost ;	**1. Accept** enables heat transfer between environment and NMR	**(2)**

Question Number	Answer	Additional Comments	Mark
(d)	1. (Cancer causing) gene identified / eq ; 2. Gene {cut / isolated / eq} from DNA / eq ; 3. Using a {restriction / eq} enzyme / eq ; 4. Gene in {vector / named vector} ; 5. Mechanism for getting {gene/vector} into host cells (of mice) / eq ;	**1. Accept** screen for the gene **2. Accept** extracted **3. Accept** correctly named restriction enzyme e.g. EcoR1 **4. Accept** Named egs – retrovirus, virus, liposome, plasmid, bacteria **5. Accept** reference to (micro)injection, microprojectiles, electroporation, gene gun, inhaler, transduction	**(3)**

Question Number	Answer	Additional Comments	Mark
* (e)	QWC – Spelling of technical terms (*shown in italics*) must be correct and the answer must be organised in a logical sequence 1. {*neurone* (cell) surface membrane exposed / no *myelination* / eq} at nodes of *Ranvier* ; 2. Nodes are the site of clusters of {*sodium-gated channel proteins / potassium channels*} ; 3. Which {open / close} when *impulse* arrives / eq ; 4. Allowing *depolarisation* at nodes / eq ; 5. idea that *myelin*/eq acts as an (electrical) *insulator* (on *neurone* surface between nodes) ; 6. reference to *Schwann* cell ; 7. idea that *impulse*/*depolarisation* 'jumps' to next node ; 8. Reference to this being *saltatory conduction* ; 9. idea that this happens between the *myelin* layers of the *Schwann* cell ;	**QWC emphasis on spelling** **3. Accept** influx of sodium ions	**(5)**

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

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

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

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

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

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

Question Number	Answer	Additional Comments	Mark
(I)	Paired responses: 1. reduced sensitivity to chemical pain / disconnection of 'pain nerves' ; 2. Idea of pain relief e.g. dealing with post traumatic pain, post surgical pain, joint pain after a knee operation ; 3. haemoglobin has higher affinity for oxygen ; 4. Idea of dealing with reduced oxygen situations such as due to a heart attack or stroke ; 5. Naked mole rat {incisors / eq } grow through skin (of lip) without damage ; 6. Idea of better prosthesis e.g. new {coatings / permanent seal} at {skin / bone / metal} interface, soft tissue not damaged, avoid infection ; 7. High protein stability / does not (easily) lose 3D shape ; 8. (so) reduced effect of oxidative {damage / stress} / reduced effect of oxygen-containing free radicals / live healthily into old age ; 9. Cell overcrowding early warning gene / ref. to two tiered contact inhibition / presence of gene p16 ; 10.Idea of cancer prevention e.g. cancer resistance, future cancer therapy ; 11.Naked mole rat neurones display immature {characteristics / physiological properties} / brain cells that cope with {low oxygen / hypoxia} ; 12.To treat people with temporary loss of oxygen to brain e.g. heart attack, stroke, drowning / to prevent permanent brain damage ; 13.High levels of oxytocin receptors in {brain / nucleus accumbens}; 14.Idea of links to autism ; 15.Naked mole rats do not experience menopause ; 16.Ref to osteoporosis {treatment / prevention} (without side effects) ; 17.circadian rhythms / sleep patterns of naked mole rats ; 18.Idea that may help with sleep disorders ;	**9. Accept** anticancer mechanism	

Q4.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • (give) {a precursor of dopamine / L-dopa} which can cross the blood brain barrier (1) • L-dopa is converted into dopamine (in the brain) (1) OR • (give) a {drug that stops the breakdown of dopamine / MAO inhibitor} (1) • that can cross the blood brain barrier (1)	ALLOW • use of {electrode / deep brain stimulation} • to stimulate basal ganglia to produce dopamine	**(2)**

Q5.

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

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

Question Number	Answer	Additional Guidance	Mark
(a)(iii)	any two of the following standardised: water / eq mineral ion concentrations / eq light intensity / eq wavelength of light CO_2 concentration, temperature pH soil type ;	ACCEPT named mineral ion	(2)

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

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

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

Question Number	Answer	Mark
(c)(ii)	<table><tr><th rowspan="2">Description</th><th colspan="3">Statement</th></tr><tr><th>Opsin binds to the rod cell membrane</th><th>Rhodopsin bleaches</th><th>ATP used</th></tr><tr><td>Rhodopsin responding to light</td><td>✓</td><td>✓</td><td>×</td></tr><tr><td>Rhodopsin being reformed</td><td>×</td><td>×</td><td>✓</td></tr></table> Any two correct for 1 mark ;	(3)

Q6.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • positive phototropism (1) (1) (1) • IAA diffuses away from light source (1) (1) • IAA accumulates in { cells / tissues } furthest from light (1) • IAA stimulates cell elongation causing growth towards light		(3)

Q7.

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

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

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to one of the following: • (seed) germination / flowering (1)	ALLOW chlorophyll synthesis / leaf development / stops growth e.g. falling leaves	**(1)**

Q8.

Question Number	Answer	Mark
(a)	(leave it) in the dark / eq ;	**(1)**

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

Question Number	Answer	Mark
(b)(ii)	1. { increase / eq} in stem length ; 2. correct manipulation of the data e.g. by 23cm / 18.4% ; 3. reference to {taller / faster growing / eq} seedling ; 4. to receive {more light / higher red light / eq} / to maximize photosynthesis / eq ; 5. idea of allows {active phytochrome / eq} to be made ;	**(3)**

Question Number	Answer	Mark
(b)(iii)	1. less red light {increases / eq} mean stem length / more far red light increases stem length / eq ; 2. the (significant) difference in mean stem length is not due to {chance / eq} / eq ; 3. the mean length for repeat was close to the original ; 4. suggesting it is likely to be reliable ;	**(3)**

Q9.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• 2.03 – 1.53 = 0.5 ÷ 2.03 x 100 (1) • = 24.63% (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to three of the following: • moving shadow and touch are perceived as presence of {danger / predator} (1) • response to touch is greater than to shadow because touch perceived as {more dangerous/ closeness of predator} (1) • response in tube is greater than response out of tube because tube provides physical surface to assist {contraction/ withdrawal} (1) • worm has receptors and those for light generate less response than those for touch (1) • when out of tube, a shadow stimulus affects all of a worm but a touch stimulus affects part of a worm (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(i)	An answer that makes reference to the following: • prevents wasting energy (1) • allows maximum feeding effort (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(ii)	An explanation that makes reference to the following: • there is less response because there is less depolarisation of the post–synaptic membrane (1) • because there are fewer calcium ions entering the pre synaptic membrane so fewer vesicles fuse with the presynaptic cell membrane (1) • so less neurotransmitter diffuses across the synaptic cleft (1) • therefore less binding to the receptors on the post– synaptic membrane so fewer sodium channels open (1) • resulting in no {action potential / impulse} in the post– synaptic neurone leading to no withdrawal response (1)	Allow description of sodium ion movement	**(5)**

Q10.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: • (isolate) the gene for ~~the~~ cytokine (from human DNA) (1) • use a bacterial plasmid (as a vector) (1) • cut the human DNA and the plasmid using the same restriction enzyme (1) • splice the gene and plasmid together using (DNA) ligase (1) • put the (modified) plasmids into bacterial cells (1)	e.g. ue a restriction enzyme to cut the DNA and the plasmid ALLOW 'join' for 'splice' ALLOW produce lots of bacteria {with the plasmid / expressing the cytokine gene}	**(4)**

Q11.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(i)	49 182 000 x 0.05 (1) 2 459 100 (1)	Correct answer gains full marks	**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(ii)	An explanation that makes reference to the following: • can dilate bronchioles /airways (1) • therefore allowing more oxygen into lungs /alveoli (1)		**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(iii)	An explanation that makes reference to the following: • sympathetic neurotransmitters are released at the SAN (1) • therefore if beta-2 agonists are present the SAN will increase its rate of stimulation (1) • so impulses will spread faster and more often over the atria (1) • therefore the heart muscle will contract more often which increases the heart rate (1)		**(4)**

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	An explanation that makes reference to four of the following: • HGH binds to receptor in cell surface membrane (1) • activation of messenger molecule in cytoplasm (1) • reference to protein kinase cascade (1) • transcription factor produced (1) • gene for IGF-1 switched on (1)		**(4)**

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	An explanation that makes reference to the following: • occur naturally / would have some present in body (1) • therefore difficult to detect additional HGH (1)		**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(d)	An explanation that makes reference to the following: • no need for blood transfusion (1) plus any one from: • therefore no risk of rejection / agglutination/ delay in {tissue/blood} typing (1) • they supply the oxygen requirements for the body (1)		**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(e)	An explanation that makes reference to four of the following: • reference to {sodium ion channels / voltage gated sodium ion channels} (1) • binding blocks movement of sodium ions into neurone (1) • membrane is not depolarised (1) • action potential is not generated (1) • no impulses conducted to brain (1)	Accept more sophisticated answers that refer to the effect on calcium ion movement	**(4)**

Question Number	Acceptable Answer	Additional guidance	Mark
(f)	An explanation that makes reference to two of the following: • (they) increase the removal of {water/salts} from blood (1) • (removal of water) lowers blood volume and therefore pressure (1) • (removal of salt) lowers uptake of water into blood (by osmosis from tissue fluid) and therefore blood pressure (1)		**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(g)	An explanation that makes reference to the following: • normal ratio is 1:1 (1) • taking testosterone and epitestosterone in equal measures maintains this ratio (1) • therefore it is not possible to detect cheats (1)		**(3)**

Question Number	Acceptable Answer	Additional guidance	Mark
(h)	An explanation that makes reference to the following: • drug E has been retained in the gas phase longer (1) • because it has {greater solubility / smaller mass} (1)	Accept more sophisticated answers related to charge	**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(i)	An explanation that makes reference to two of the following: • longitudinal monitoring / to be followed over time (1) • therefore can identify individual differences in naturally occurring drug concentrations (1) • therefore can see pattern or link to competition / injury / look for changes (1)		**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(j)	An answer that makes reference to the following: • the absolutist's view would be that they should never be used (1) plus any one from: • because of the damage to the body by the side effects (1) • athletes should compete using their innate {anatomical / physiological} abilities / fair competition should be promoted (1) and • the rationalist's view would be that their use is acceptable if there is a justifiable outcome (1) Plus any one from: • because it is a personal choice (1) • because it could help to overcome the inequalities in {training / medical support} (1)		**(4)**

Q12.

Question Number	Acceptable Answer	Additional Guidance	Mark
	C		**(1)**

Q13.

Question Number	Answer	Mark
(a)(i)	B ;	**(1)**

Question Number	Answer	Mark
(a)(ii)	D ;	**(1)**

Question Number	Answer	Mark
(a)(iii)	A ;	**(1)**

Question Number	Answer	Mark
(a)(iv)	D ;	**(1)**

Question Number	Answer	Mark
(a)(v)	A ;	**(1)**

Question Number	Answer	Additional guidance	Mark
(b)	1. Ideas of (muscles) work antagonistically ; 2. circular muscle relaxes ; 3. radial muscle contracts;	ACCEPT 2 stretched	**(2)**

Q14.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • transfer of antibiotic-resistance gene to other microorganisms (1) • a reason associated with health (1)	e.g. pathogenic bacteria developingresistance to antibiotics	**(2)**

Q15.

Question Number	Answer	Mark
(a)		Comp (3)

Description	Area of the rod cell			
	A	B	C	D
Nearest the pupil of the eye	☒	☒	☒	☒
Containing the photosensitive pigment	☒	☒	☒	☒
Has the pre-synaptic membrane	☒	☒	☒	☒

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

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

Q16.

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

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

Q17.

Question Number	Answer	Additional Guidance	Mark
(a)	1. involves prophase, metaphase, anaphase and telophase ; 2. idea that produces two nuclei ; 3. idea that these are genetically identical to original ;	1. NOT if cytokinesis or interphase included as part of mitosis 2. ACCEPT produces two cells	(2)

Question Number	Answer	Additional Guidance	Mark
(b)	1. (SAN) is myogenic / description given ; 2. electrical activity from SAN causes atria to contract / eq ; 3. idea that activity of SAN can be changed by nerve impulses e.g. controlled by medulla ; 4. credit detail of nervous control e.g. more impulses from accelerator increases heart rate ;		(3)

Question Number	Answer	Additional Guidance	Mark
(c)	1. idea that lactase gene {activated / transcribed} ; 2. (synthesis of) lactase / eq ; 3. hydrolysis of lactose / glycosidic bonds broken ; 4. to produce glucose AND galactose ;		(3)

Question Number	Answer	Additional Guidance	Mark
(d)	1. idea that a better model than guinea pigs or mice ; 2. idea of animal rights ; 3. easy to culture / eq ; 4. (HeLa cells) susceptible to disease / HPV / eq ;	1. ACCEPT reference to only HeLa {cells / DNA} are human 3. ACCEPT cheaper (as continual supply)	**(2)**

Question Number	Answer	Additional Guidance	Mark
***(e)**	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence) 1. idea that {motor neurone / cell body / nucleus} is destroyed ; 2. depolarisation does not occur in the neurone / (insufficient so) no action potential set up in the neurone ; 3. detail of (depolarisation / action potential) not occurring in neurone e.g. idea Na^+ does not diffuse into neurone ; 4. {neurotransmitter / named neurotransmitter} not {released / produced / eq} at junction with muscle / eq ; 5. detail of lack of neurotransmitter release e.g. vesicles (containing neurotransmitter) do not {move / fuse} with {presynaptic membrane /	QWC emphasis is clarity of expression 1. ACCEPT idea of damage to myelin sheath / Schwann cells 3. ACCEPT Na^+ / cation channels {non-functional / eq} 4. ACCEPT {neurotransmitter / named neurotransmitter} not {released / produced / eq} at {motor neurone presynaptic membrane / motor end plate}	

	eq} / eq ; 6. Ca^{2+} not released into muscle cytoplasm ; 7. Ca^{2+} not released from sarcoplasmic reticulum ; 8. no Ca^{2+} to {activate / eq} troponin ; 9. idea that muscle does not contract ;	6. ACCEPT Ca^{2+} not released into sarcoplasm	**(6)**

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

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

Question Number	Answer	Additional Guidance	Mark
(h)	1. all the {DNA / eq} found in {a human / the human species / eq} ; 2. idea of genes {on different chromosomes / different positions on same chromosome} ;	1. ACCEPT population for species	(2)

Question Number	Answer	Additional Guidance	Mark
(i)	1. product (of p53 gene) {stops / eq} development of tumour cells / eq OR product (of p53 gene) {stops / regulates} progression {of cell cycle / towards mitosis} ; 2. acts as an inhibitor of {transcription / protein synthesis / eq} / eq ; 3. idea that {DNA / eq} repair ; 4. idea that leads to apoptosis ;	1. ACCEPT product stops tumour cells growing / dividing 1. ACCEPT product keeps it in {interphase / named mitotic stage} / product interferes with mitosis progress	(2)

Question Number	Answer	Additional Guidance	Mark
(j)	1. protein / glycoprotein ; 2. reference to this being CD4 ; 3. found on cell (surface) membrane / eq ; 4. that acts as a {receptor / named receptor} for HIV / eq ;	4. ACCEPT receptor for gp120	(2)

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

Q18.

Question Number	Answer	Additional guidance	Mark
(a)	1. chromosomes / eq (continue to) condense ; 2. nuclear envelope breaks down ; 3. spindles (fibres) form ; 4. nucleolus breaks down / eq ;		**(3)**

Question Number	Answer	Additional guidance	Mark
(b)	1. (pH sensitive cells) detect a change in blood pH / eq ; 2. these are in the {carotid body / carotid artery / aortic body / aorta / medulla } ; 3. alter impulse rate to brain / eq ; 4. reference to cardiac centre ; 5. in medulla ; 6. change impulse rate of SAN ;		**(4)**

Question Number	Answer	Additional guidance	Mark
(c)	1. idea that reproduce rapidly / {robust / hardy} so many can be formed rapidly ; 2. easy to culture / eq ; 3. (HeLa cells) susceptible to disease / HPV / eq ; 4. genome known / eq ; 5. idea that they have no Hayflick limit ;	2. ACCEPT cheaper (as continual supply) 3. ACCEPT other named disease 4 ACCEPT reference to (HeLa) cells are human	**(3)**

Question Number	Answer	Additional guidance	Mark
*(d)	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence) 1. phospholipid bilayer ; 2. idea of its hydrophobic properties inhibit movement of ions across membrane ; 3. Na^+ gated channel present ; 4. to allow Na^+ to enter during depolarisation / to open when local currents occur ; 5. K^+ channels ; 6. to allow K^+ to diffuse ; 7. sodium–potassium pump / eq ; 8. to {export Na^+/ import K^+} ; 9. role of pump in neurone membrane ; 10. idea that only parts of the membrane may be involved e.g. nodes of Ranvier ;	QWC emphasis is logical sequence 10. ACCEPT salutatory condition ;	**(6)**

Question Number	Answer	Additional guidance	Mark
(e)	1. idea of double stranded only in HeLa ; 2. idea of to many H bonds in HeLa / {complementary bases / base pairs} ; 3. thymine only found in HeLa genetic material / uracil only in poliovirus ; 4. sugar present in HeLa is deoxyribose / ribose in poliovirus / eq ;		(3)

Question Number	Answer	Additional guidance	Mark
(f)	1. brown shown as dominant / white shown as recessive e.g. use of upper and lower case; **Parental generation:** 2. both types shown as homozygous ; **F1:** 3. all shown as heterozygous ;		

	F2: 4. genetic diagram to show that 75% are brown / 25% are white ;	4. Diagram should show genotypes	**(4)**

Question Number	Answer	Additional guidance	Mark
(g)	1. allow continual division (of hybrid) ; 2. idea of continual production of (monoclonal) antibodies ;	1. ACCEPT division is rapid / eq;	**(2)**

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

Question Number	Answer	Mark
(i)	D (2^{50}) ;	**(1)**

Question Number	Answer	Additional guidance	Mark
(j)	Any two for 1 mark: Carbon / hydrogen / oxygen / nitrogen ; ;	ACCEPT as chemical symbols	**(2)**

Q19.

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

Q20.

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

Question Number	Answer	Mark
(ii)	A ;	**(1)**

Q21.

Question Number	Answer	Additional Guidance	Mark
*	**(QWC – Spelling of technical terms must be correct and the answer must be organised in a logical sequence)** 1. identify a gene that {provokes an effective immune response / codes for {antigen / eq} / inhibits *T. gondii* entering {brain/muscle} cells} ; 2. gene removed using a {restriction enzyme / endonuclease} ; 3. {same / this / eq} restriction enzyme used to open {*T. gondii* genome / eq} / eq ; 4. sticky ends {formed / eq } ; 5. ligase used to bind gene / eq ; 6. by forming phosphodiester bonds / eq ; 7. idea of method of introducing gene into pathogen ; 8. idea that gene needs to be expressed e.g. protein synthesised ; 9. idea of this protein in provoking an immune response ; 10. detail of immune response ;	QWC with emphasis on clarity of expression 3. **NOT** plasmid cut open 7. **IGNORE** plasmid 8. **ACCEPT** synthesises antigen	**(6)**

Q22.

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

Q23.

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

Q24.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to the following: • calcium ions enter presynaptic neurone so vesicles with neurotransmitter can {move towards / fuse withpresynaptic membrane} (1) • neurotransmitter molecules diffuse across thesynapse (1) • neurotransmitter to bind with receptors on postsynaptic membrane (on the brain cell) (1) • sodium ions diffuse into {brain cell / post-synaptic cell}leading to {a depolarisation / an action potential } (1)	ALLOW calcium ions enter presynaptic neurone leading to exocytosis of neurotransmitter from vesicles ALLOW named neurotransmitter such as acetylcholine, dopamine, noradrenaline ALLOW enter for diffuse	**(4)**

Question Number	Answer	Mark
(ii)	**The only correct answer is B - U – This is the site in the brain where the image is interpreted** ***A*** *is not correct because* T is not the site in the brain where the image is interpreted ***C*** *is not correct because V* is not the site in the brain where the image is interpreted ***D*** *is not correct because* W is not the site in the brain where the image is interpreted	**(1)**

Q25.

Question number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to two of the following: • frequency of light-off pulses (1) • duration of light-off pulse (1) • {wavelength / intensity} of light (1)	ALLOW interval between {pulses / turning lights off}	Expert (2)

Question number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to three of the following: • (with reduced synapsis) habituation is not as complete / there was a greater percentage of maximum jump response (1) • (with reduced synapsin) habituation takes place more slowly / jump-response decreases more slowly (1) • appropriate {manipulation / comparative use of data} (1)	ALLOW converse for normal synapsin ALLOW higher jump-response / jumpedmore e.g. jump response decreases by (14-4) 10% more with normal synapsin / takes (305) 25 more light-off stimuli to get maximum response for reduced synapsin after 100 light stimuli 16% higher with reduced synapsin	Expert (3)

Question number	Answer	Additional guidance	Mark
(iii)	An explanation that makes reference to three of the following: • (reduced synapsin) increases the number of vesicles fusing with the presynaptic membrane (1) • (resulting in more) {exocytosis / release} of neurotransmitter (into the synapse) (1) • therefore, (more) action potentials generated in post synaptic membrane (1) • therefore the flies (continue to) respond to the light-off stimulus (1)	ALLOW vesicles can continue to fuse ALLOW (more) depolarisation of post synaptic membrane	Expert (3)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to two of the following: • period of time during early development (1) • when the nervous system must obtain specific experiences to develop properly (1) • so that synapses are strengthened / unstimulated synapses are removed (1)	ALLOW retina needs to be exposed to light ALLOW when visual columns are organised	**(2)**

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of { largest difference in concentration / largest value at 0 minutes and smallest value at 30 minutes } (1) • calculation of rate of decrease in nicotine concentration per minute (1)	Example of calculation (35.0 + 9.3) / 44.3 and (24.1 – 5.6) / 18.5 25.8 ÷ 30 = 0.86 Correct answer without working gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to two of the following: • percentage change greater for {the lower concentration of / 0.1 mg } nicotine (1) • a higher concentration causes a positive (percentage) change whilst the lower concentration leads to a negative (percentage) change (1) • correct calculation of percentage change for both rat groups (1)	2.08% for { 1.0 mg nicotine / group A } and 6.25% for { 0.1mg nicotine / group B }	(2)

Question Number	Indicative content
*(iii)	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Give examples of relevant biological knowledge and understanding: <u>Validating the statement</u> • Investigation involved rats inhaling nicotine which humans do during smoking • Rats are mammals so can extrapolate to humans <u>Not validating the statement</u> • Nicotine inhaled (for both nicotine concentrations) leads to vasoconstriction and then vasodilation and then returns to original diameter • Blood pressure for 1mg nicotine concentration increases and decreases but drops below original value • Presence of nicotine leads to noradrenaline release which increases heart rate • Blood pressure (for both nicotine concentrations) increases and decreases • No reference to rats inhaling smoke, only nicotine • Rats are not the same as humans • Sample size too small to make a valid statement <u>Comment</u> • whether agree or disagree with statement

			Additional guidance
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	An answer that refers to just one piece of evidence – either lumen size or blood pressure Simple conclusion drawn from the evidence
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	An answer that refers to evidence concerning both lumen size and blood pressure Links made between lumen size, vasoconstriction and blood pressure
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	An answer that refers to data about vasoconstriction and vasodilation and links it to effect of nicotine on the release of noradrenaline and therefore on blood pressure Conclusion made considering validity of data collected from rats and how it can be applied to humans

Q3.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • increasing light intensity decreases the current (1) • because {rhodopsin is broken down / opsin is released} (1) • therefore, more opsin binds to the channel proteins in the outer segment (1) • sodium-gated voltage channels close (1) • {reducing / stopping} the influx of sodium ions / making membrane impermeable to sodium ions (1)	ALLOW opsin binds to the cell surface membrane / sodium-gated voltage channels ALLOW Na^+ channels / (non-specific) cation channels for sodium-gated voltage channels	**(5)**

Q4.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • as they age Drosophila climb {less high / more slowly} (1) • (the expression of) 0N3R or 0N4R further {reduce theheight climbed / slow down} the Drosophila (1) • 033R has a greater effect than 0N4R (1)	ALLOW tau proteins / both tau proteins reducedheight climbed ALLOW fly in place of climb ALLOW 033R affected the flies the most	Choose an item. (3)

Q5.

Question number	Answer	Additional guidance	Mark
(i)	A description that makes reference to two of the following: • shading (coleoptile tip) reduces / stops bending (1) • light {detecting / sensitive} part of coleoptile is in first 5 mm (1) • no (significant) difference between {(exposure for) 2 or 3 hours / (shading of) 5 mm or 10 mm} (1)	ALLOW as (length of) shading increases degree of bending decreases ALLOW converse ALLOW part of coleoptile that bends is below the part that detects light	Expert (2)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following: • {5% / 1 in 20} probability (1) • the results (obtained) occurred by chance (1) OR • 95% probability (1) • the results (obtained) did not occur by chance (1)	IGNORE reference to null hypothesis ALLOW less than 5% ALLOW probability of 0.05 DO NOT ALLOW results are {accurate / correct / wrong}	Expert (2)

Q6.

Question number	
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Indicative content** Information • there are 20 000 different proteins • these proteins carryout different functions • there are a {large number of / 20} different {R groups / amino acids} • most R groups are non-polar, some are polar a few have a charge Linkage to **s**tructure • R groups determine {3D shape / structure} of proteins • {large number of / 20 R groups} • many combinations of amino acids required to give wide variety of protein structures • R groups can form bonds to stabilise 3D structure (e.g. cysteine) • role of R-groups in structure of haemoglobin • role of R-groups in structure of collagen • location of cysteine allows formation of disulfide bonds Linkage to **f**unction • R groups variety of protein shapes are required to allow proteins to carry out wide range of functions • examples of functions that require specific structure e.g. antibodies specific to an antigen / enzymes specific for a substrate / receptors e.g. neurotransmitters and (acetylcholine) and ion-gated channels • polar / ionic R groups increase solubility • non-polar R groups will be on outside of insoluble proteins / structural proteins / collagen / proteins inserted into membranes • role of R-groups in function of haemoglobin • role of R-groups in function of collagen Linkage to **l**ocation • polar R groups will be in aqueous environment /non-polar regions in a non-aqueous environment

	• polar /ionic R groups soluble in {plasma/ tissue fluid / cytoplasm} / line the inside of ion channels / found on the outside of soluble proteins such as hormones / transport proteins / immunoglobulins / cytokines • role of R-groups in location of haemoglobin • role of R-groups in location of collagen

Level	Marks		
0	0	No awardable content	
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	Selection of some information from the table – little or no linkage Linkage to one aspect – 2 marks Two linkages for same aspect – 3 marks
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	Linkage between R groups and two aspects from structure, function and location One comment on each - 4 marks An additional comment - 5 marks An additional 2 comments – 6 marks
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.	Linkage between R groups and all three aspects (structure, function and location) One comment on each - 7 marks
		The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	An additional comment - 8 marks An additional 2 comments – 9 marks

Q7.

Question number	Answer	Additional guidance	Mark
	• correct length calculated	3.3 / 3.33	Clerical (1)

Q8.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to five of the following: • light is detected by rod cells (1) • rod cell membrane is hyperpolarised (1) • stopping the release of the inhibitory neurotransmitter glutamate (1) • bipolar neurone is depolarised (1) • impulse transmitted along {ganglion neurone / optic nerve} (1) • (impulse transmitted) to visual cortex of the brain (1)	ALLOW description of role of rhodopsin ALLOW occipital lobe	**(5)**

Q9.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • (IAA) produced in the tip of the shoot (1) • (IAA) accumulates on the dark side of the shoot (1) • (IAA) stimulates cell elongation (1) • causing the shoot to grow towards the light source (1)	ALLOW a diffusion gradient is established / IAAdiffuses to the opposite side of the shoot ALLOW low concentrations of IAA inhibit cellelongation on the light side ALLOW plant ALLOW bend	Choose an item. (4)

Q10.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: Similarities • both have a cell body containing a nucleus (1) • both have an axon (1) • both have dendrites at one end of neurone and terminal branches at the other end (1) Difference • location of cell body (1)	IGNORE descriptions of function ALLOW motor neurone cell body is at one end of the axon whereas in the sensory neurone the cell body is located along the axon	**(4)**

Q11.

Question number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following: • acetylcholinesterase breaks down acetylcholine (1) • inhibitor prevents break down of acetylcholine (1) • so more (acetylcholine) is available to bind to post-synaptic {membrane / receptors} (1) • therefore compensating for the {reduced production of acetylcholine / loss of acetylcholine producing neurones} (1)	ALLOW blocks acetylcholinesterase ALLOW inhibiting acetylcholinesterase maintains higher concentrations of acetylcholine (in synapse) (1)	Choose an item. (3)

Question number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following: • concentration between 25 and 50 μmol dm^{-3} (1) • concentration having greatest inhibitory effect (1) • but having no effect on cell viability (1)	ALLOW any value between 25 and 50 ALLOW suitable description of effect e.g. reduces enzyme activity by {more than 50% / 60% / 2.4 a.u. ALLOW viability remains at 100%	Choose an item. (3)

Q12.

Question Number	Answer	Mark
(i)	**C** - retinal *The only correct answer is **C*** ***A** is incorrect because IAA is auxin* ***B** is incorrect because opsin is the protein part and not the non-protein* ***D** is incorrect because rhodopsin is the pigment*	**(1)**

Question Number	Answer	Mark
(ii)	**A** *The only correct answer is **A*** ***B** is incorrect because it is the hypothalamus* ***C** is incorrect because it is the medulla oblongata* ***D** is incorrect because it is the cerebellum*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: • (fMRI) detects { blood flow / oxygen use } in the brain • increased brain activity results in increased { blood flow / demand for oxygen / aerobic respiration } in the area of activity • oxyhaemoglobin absorbs fewer radio waves / fMRI detects areas where less signal absorbed	ALLOW signal reflected by oxyhaemoglobin	**(3)**

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to two of the following: • transcription (of the DNA containing the mutation) / transcribe to produce { mRNA / RNA } • using { RNA nucleotides / RNA polymerase }	IGNORE translation	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • individuals have different mutations / targets an individual's specific mutation • the RNA molecule used will be specific to { each mutation / individual }	ALLOW mutations at different loci	**(2)**

Q14.

Question Number	Answer	Additional Guidance	Mark
	1. idea that there was no bias ; 2. idea of contributes to validity ; 3. idea of hot object desensitises ; OR idea of thermoreceptors not harmed /overstimulated / habituated due to high temp ;	**1. ACCEPT** sequence of procedure has no effect/to see if positive then negative gives a different outcome to negative then positive	**(2)**

Q15.

Question Number	Answer	Additional Guidance	Mark
	1. idea that opsin uncouples from the (rod cell) cell surface membrane ; 2. trans retinal {converts / eq} to cis retinal ; 3. rhodopsin is (re)formed / eq ; 4. from opsin and retinal ; 5. idea that this results in dark adaptation ; 6. permeability of the cell surface membrane to Na^+ increases / eq ; 7. hyperpolarisation of cell decreases / eq ; 8. (more) neurotransmitter is released / eq ;	**NB IGNORE** ***references to bipolar neurone responses*** **IGNORE** reference to retinol **6. ACCEPT** Na^+ {enters /channels unblocked / channels open} **7. ACCEPT** (partial) depolarisation / reduced potential difference **8. ACCEPT** glutamate for neurotransmitter	**(5)**

Q16.

Question Number	Answer	Mark
	The only correct answer is **A** – CT uses X-rays that can cause mutations in the DNA of muscle fibres ***B*** *is incorrect because mutations do not occur in protein* ***C*** *is incorrect because CT does not use magnets* ***D*** *is incorrect because CT does not use magnets and mutations do not occur in protein*	**(1)**