

Question			Expected Answer	Mark	Additional Guidance
1	(a)	(i)	<p>1 <i>idea that</i> (produces) large , yield / volume / amount, of milk ;</p> <p>2 <i>idea of</i> long lactation period ;</p> <p>3 <i>idea of</i> high milk quality ;</p> <p>4 large udders / correct udder shape (for milking machine) ;</p> <p>5 resistance to , (named) disease / mastitis / pathogens or effective immune system ;</p> <p>6 <i>idea of</i> calm temperament ;</p> <p>7 AVP ;</p>	3 max	<p>Mark the first suggestion on each line</p> <p>1 DO NOT CREDIT milk yield unqualified</p> <p>2</p> <p>3 DO NOT CREDIT milk quality unqualified or ref. meat</p> <p>4</p> <p>5 DO NOT CREDIT disease free</p> <p>6 CREDIT docile / placid</p> <p>7 eg • walk / stand , comfortably without need for hoof-trimming • <i>idea that</i> converts food to milk efficiently</p>
1	(a)	(ii)	<p>normal shaped curve ;</p> <p>shifted to the right of original ;</p>	2	<p>Position of curve must meet the following conditions:</p> <ul style="list-style-type: none"> • curve must end to right of original end • must not start to left of original • may start at same point as original or to right of original

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1	(a)	(iii)	<p>1 artificial insemination / AI ;</p> <p>2 in vitro fertilisation / IVF ;</p> <p>3 <i>idea of</i> progeny testing ;</p> <p>4 embryo transplantation / use of surrogate mother ;</p> <p>5 cloning ;</p> <p>6 genetic screening / use of gene probes ;</p> <p>7 AVP ;</p> <p>8 AVP ;</p>	2 max	<p>Mark the first suggestion on each line</p> <p>1 IGNORE performance testing</p> <p>2</p> <p>3</p> <p>4 CREDIT embryo splitting</p> <p>5</p> <p>6 ACCEPT genetic engineering</p> <p>7 eg • sex selection technique / screening X and Y sperm</p> <p>8 eg • portmanteau animals</p>
1	(b)	(i)	<i>idea of</i> change to , <u>DNA</u> / <u>base(s)</u> / <u>nucleotide(s)</u> ;	1	
1	(b)	(ii)	natural / directional , selection ;	1	ACCEPT evolution DO NOT CREDIT genetic drift
1	(c)	(i)	<p><i>regulatory</i> <i>idea that</i> makes , repressor protein / transcription factor or <i>idea that</i> product switches (structural / another) gene , on / off ;</p> <p><i>structural</i> <i>idea that</i> makes , enzyme / polypeptide / protein ;</p> <p><i>relationship between the 2</i> <i>idea that</i> regulatory <u>gene</u> , controls / affects , the expression of structural <u>gene</u> ;</p>	2 max	<p>ACCEPT ‘makes regulatory protein’</p> <p>ACCEPT ‘switching on / off’ for idea of control IGNORE explanation involving repetition of word “regulates”</p>

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1	(c) (ii)	<p>lactose has been , removed / digested / respired / broken down (by bacteria) ;</p> <p>to , lactic acid / lactate / other sugars ;</p> <p>yogurt still a good source of , calcium / vitamins ;</p>	2 max	<p>DO NOT CREDIT if context wrong (eg heat)</p> <p>eg • glucose (and galactose)</p>
1	(d)	<p>1 lactose binds to repressor protein ;</p> <p>2 changes , shape / structure (of protein) ;</p> <p>3 removes it from / stops it binding to , operator ;</p> <p>4 RNA polymerase binds to promoter ;</p> <p>5 <i>idea that</i> (so that Z and Y) are , transcribed / <u>m</u>RNA made ;</p>	3 max	<p>1 DO NOT CREDIT regulator substance</p> <p>2 IGNORE ref. to active site</p> <p>3</p> <p>4 DO NOT CREDIT DNA polymerase</p> <p>5 CREDIT lactose permease and β-galactosidase for Z and Y</p> <p>IGNORE gene , switched on / expressed</p>
Total			16	

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2	(a)		voluntary (skeletal)	involuntary (smooth)	cardiac	<p>For each box, mark the first answer that will result in a mark being awarded. If an additional answer is given that is incorrect or contradictory then = 0 marks</p> <p>IGNORE information in second or third boxes across row that is identical to 1st or 2nd box – each box should be different (as Q asks for differences between the types)</p> <p>eg striated(✓) unstriated(✓) striated = 2</p> <p> multinucleate(✓) uninucleate(✓) uninucleate = 2</p> <p> striated(✓) unstriated(✓) striated multinucleate uninucleate uninucleate(✓) = 3</p> <p>CREDIT drawings if feature such as striated / multinucleate / uninucleate, are clearly shown</p> <p>* ACCEPT description of striated / non striated (eg stripey)</p> <p>** ACCEPT control , blood pressure / diameter of blood vessels / diameter of airways</p> <p>** CREDIT vasoconstriction / vasodilation , for controlling diameter of blood vessels</p>
		cellular structure	*striated / bands of actin & myosin or cylindrical cells or multinucleate ;	*unstriated / *non striated or spindle-shaped cells or uninucleate ;	*striated or branched cells or uninucleate or interlocking / junctions / intercalated discs ;	
		function	to move , bones / skeleton / joints / (named) limbs ;	<i>idea of</i> **controlling diameter of , arteries / arterioles / bronchi / bronchioles or peristalsis or uterine contraction or control pupil size ;	to pump blood / AW ;	
					6	

Question		Expected Answer	Mark	Additional Guidance
2	(b)	<p><i>voluntary</i> intercostal / diaphragm ;</p> <p><i>involuntary</i> bronchi / bronchioles / arteries / arterioles / aorta / oesophagus ;</p> <p><i>cardiac</i> heart ;</p>	3	<p>CREDIT trapezius / deltoid / pectorals / latissimus dorsi / rotator cuff muscles ACCEPT 'between the ribs' for intercostal</p> <p>DO NOT CREDIT named artery not found in thorax IGNORE gut unqualified</p> <p>ACCEPT walls of , atria / ventricle(s)</p>
2	(c)	<p>(cardiac) D ; (clapping) B ; (bicycle) C ;</p>	3	
2	(d)	<p><i>monkeys rather than rats</i></p> <p>1 <i>idea that</i> (humans & monkeys) closely related / share more genes / share a common ancestor ;</p> <p>2 (humans & monkeys) both <u>primates</u> ;</p> <p>3 <i>idea that</i> brain / body , structure / physiology / behaviour , similar (to humans) ;</p> <p>4 monkey brain bigger (than rat) ; max 2</p> <p><i>comment</i></p> <p>5 argument in favour ;</p> <p>6 argument against ; max 2</p>	3 max	<p>MAXIMUM 2 marks from either section</p> <p>1 DO NOT CREDIT 'monkeys are closest ancestors to humans'</p> <p>2</p> <p>3 ACCEPT having a similar response to treatment</p> <p>4</p> <p>5 eg • to alleviate human suffering / can save lives</p> <p>6 eg • causes , pain / distress / stress , to monkeys DO NOT CREDIT 'cruel to monkeys' unqualified 'right to life of monkeys' / monkeys killed</p>

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Question	Expected Answer	Mark	Additional Guidance
2 (e)	<p><i>appropriate parts of nervous / endocrine systems</i></p> <p>1 sympathetic (motor neurones) stimulated ; 2 <u>noradrenaline</u> / <u>norepinephrine</u> ; 3 neurotransmitter released at , neurovascular junction / organs ; 4 <u>adrenaline</u> (secreted / released into blood) ; 5 from <u>adrenal</u> , <u>glands</u> / <u>medulla</u> ; 6 <i>idea of</i> adrenaline / noradrenaline , binding to receptors (on target tissue) ; 7 AVP ;</p> <p><i>effect on structures containing 3 types of muscle</i></p> <p>C8 <i>idea of</i> heart beats faster ; C9 <i>idea of</i> heart beats more forcefully ;</p> <p>S10 alter blood flow / increase blood pressure ; S11 less blood flow to , gut / skin ; S12 reducing gut secretions / making skin pale ; S13 smooth muscle in gut relaxes / peristalsis slows down ; S14 smooth muscle in airways relaxes / airways wider ; S15 iris radial muscle contracts / pupil dilates ;</p> <p>V16 <i>idea of</i> breathing / intercostals contracting / diaphragm contracting , faster ; V17 more blood flow to (skeletal) muscles ; V18 <i>idea of</i> (named skeletal) muscles being primed for action ;</p> <p>19 AVP ;</p>	<p>8 max</p>	<p>ACCEPT phonetic spelling throughout</p> <p>1 2 3 May be awarded in the context of acetylcholine 4 5 6 7 eg • correct ref to corticosteroids • correct ref to medulla oblongata</p> <p>C = cardiac C8 C9 S = smooth S10 eg • constriction / dilation , of arterioles S11 S12 S13 ACCEPT involuntary for smooth S14 ACCEPT involuntary for smooth S15 V = voluntary V16 V17 V18 ACCEPT 'leg muscles' as named eg CREDIT glycogenolysis in muscle for priming</p> <p>19 eg • erector pili muscles raise hairs</p>
	<p>QWC – linking structure to response ;</p>	<p>1</p>	<p>Award if 2 different mps from mps 1 – 7 correctly linked to 2 different mps from mps C7 – V17</p>
	<p>Total</p>	<p>24</p>	

Question		Expected Answer	Mark	Additional Guidance																								
3	(a)	<p><i>climate - tropical versus temperate</i> <i>tropical has ...</i></p> <p>1 higher temperature / hotter ; 2 more (sun)light / days longer ; 3 photosynthesis faster ;</p> <p>4 <i>idea that</i> more storage of , organic molecules / biomass / energy or more formation of , organic molecules / biomass ;</p> <p>5 AVP ;</p> <p><i>vegetation - woodland or rainforest versus grassland(s)</i> <i>woodland or forest has ...</i></p> <p>6 <i>idea of</i> greater complexity / greater biodiversity / more niches ; 7 competition for space less limiting ; 8 AVP ;</p>	4 max	<p>CREDIT reverse arguments for temperate</p> <table border="1"> <thead> <tr> <th></th> <th><i>tropical</i></th> <th><i>temperate</i></th> </tr> </thead> <tbody> <tr> <td><i>temperature</i></td> <td>higher</td> <td>lower</td> </tr> <tr> <td><i>light intensity</i></td> <td>more</td> <td>less</td> </tr> <tr> <td><i>photosynthesis</i></td> <td>more</td> <td>less</td> </tr> <tr> <td><i>biomass made</i></td> <td>more</td> <td>less</td> </tr> </tbody> </table> <p>eg</p> <ul style="list-style-type: none"> • less seasonal change • faster , mineral cycling / decomposition <p>CREDIT reverse arguments for grassland</p> <table border="1"> <thead> <tr> <th></th> <th><i>wood</i></th> <th><i>grassland</i></th> </tr> </thead> <tbody> <tr> <td><i>complexity</i></td> <td>more</td> <td>less</td> </tr> <tr> <td><i>competition</i></td> <td>less</td> <td>more</td> </tr> </tbody> </table> <p>eg</p> <ul style="list-style-type: none"> • greater , humidity / shelter 		<i>tropical</i>	<i>temperate</i>	<i>temperature</i>	higher	lower	<i>light intensity</i>	more	less	<i>photosynthesis</i>	more	less	<i>biomass made</i>	more	less		<i>wood</i>	<i>grassland</i>	<i>complexity</i>	more	less	<i>competition</i>	less	more
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<i>competition</i>	less	more																										
3	(b)	<p>(bomb) calorimeter ;</p> <p>detail of technique ;</p> <p>detail of , measurement / analysis ;</p>	2 max	<p>eg</p> <ul style="list-style-type: none"> • known / dry , mass of (organic material) • (material) burnt in oxygen <p>eg</p> <ul style="list-style-type: none"> • temperature rise of water measured • known volume of water • calculation described / converted to kJ 																								

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Question			Expected Answer		Mark	Additional Guidance	
3	(c)	(i)	(perch) 22 ; (cow) 1 ;		2		
3	(c)	(ii)	1	higher in bobcat / lower in cow ; <i>for bobcat</i>	3 max	1	DO NOT CREDIT figs alone IGNORE refs to grasshopper and perch ALLOW ecf if cow calculated as > 6 in (i)
			2	more (energy) absorbed ; ora		2	
			3	less (energy / waste) egested ; ora		3	
			4	correct comparative figs. quoted from table ;		4	bobcat 83(%) <u>and</u> cow 40(%) (absorbed) or bobcat 17(%) <u>and</u> cow 60(%) (egested)
			5	meat more digestible ; ora		5	
			6	mainly protein and fat ;		6	
			7	contains no <u>cellulose</u> ; ora		7	
3	(c)	(iii)	1	<u>grasshopper</u> ;	3 max	If perch is suggested, candidate can only access mp 2 = max 1	
			2	<i>idea of</i> high conversion to biomass figure ;		2	If bobcat or cow suggested, then = 0 ACCEPT ref to more energy accumulated in body ACCEPT mp2 in context of perch for max 1
			3	<i>idea of</i> herbivore / primary consumer / low(er) trophic level than perch ;		3	
			4	<i>idea of</i> more food available ;		4	
			5	<i>idea of</i> one stage of energy loss in food chain not two / more energy passes through food chain (to humans) ;		5	
Total					14		

Question			Expected Answer	Mark	Additional Guidance
4	(a)	(i)	<p><i>description</i></p> <p>1 lactose decreases <u>and</u> qualified ;</p> <p>2 ammonia decreases <u>and</u> qualified ;</p> <p>3 ammonia , plateaus / constant , at c. 2 (a.u.) (between 55 -140 h) ; max 2</p> <p><i>explanation</i></p> <p>4 <i>idea that</i> lactose / ammonia , used , for growth / to make biomass ;</p> <p>5 lactose / ammonia , used to make penicillin ;</p> <p>6 lactose broken down to glucose (and galactose) ;</p> <p>7 lactose / glucose , used for , respiration / energy ;</p> <p>8 ammonia used to make named N-containing molecule ; max 2</p>	4 max	<p>max 2 for description and max 2 for explanation</p> <p>If bacteria mentioned, penalise once and then apply ecf.</p> <p>If incorrect units used, penalise the mark point and then apply ecf for subsequent mark points.</p> <p>1 eg • single figure quote either at start (96 / 97 (a.u.)) or levelling-off point (45 - 60 h) or end (65 -70 h)</p> <p>2 eg • single figure quote either at start (34 (a.u.)) or levelling-off point (40 - 55 h)</p> <p>3</p> <p>4</p> <p>5</p> <p>6</p> <p>7 IGNORE ammonia</p> <p>8 eg • amino acids / protein / nucleotides / nucleic acids / chitin / glycoprotein</p>

Question			Expected Answer	Mark	Additional Guidance
4	(a)	(ii)	<p>lactose and ammonia levels , stay high / oscillate ;</p> <p>biomass , continues to rise / does not level off ;</p>	2	<p>If bacteria mentioned, penalise once and then apply ecf. IGNORE incorrect ref to stationary phase</p> <p>DO NOT CREDIT 'remains constant' without the idea of more being added</p> <p>ACCEPT 'biomass , rises and falls / levels off' only if reference made to harvesting / removal</p>
4	(a)	(iii)	<p><i>idea that</i> most penicillin produced after main growth phase ; after 24 h / when nutrients declining ;</p> <p>not needed for growth ; (however evidence not entirely clear as) production begins during biomass log phase ;</p>	2 max	<p>If bacteria mentioned, penalise once and then apply ecf. IGNORE incorrect ref to stationary phase</p>
4	(b)	(i)	<p>1 to avoid unwanted microbe , entry / presence ;</p> <p>2 so no competition for nutrients ;</p> <p>3 so conditions remain unchanged ;</p> <p>4 so no decrease in yield ;</p> <p>5 so no contamination of , batch / product / penicillin or batch is unusable ;</p> <p>6 to prevent escape of , microbes / fungus / <i>Penicillium</i> / spores ;</p>	3 max	<p>If bacteria mentioned, penalise once and then apply ecf.</p> <p>1 : IGNORE pathogens</p> <p>2 :</p> <p>3 :</p> <p>4 :</p> <p>5 : DO NOT CREDIT contamination unqualified</p> <p>6 :</p>

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4	(b)	(ii)	temperature - as it affects enzymes ; pH - as it affects enzymes ; oxygen content – ref. respiration ; AVP ;	3 max	If bacteria mentioned, penalise once and then apply ecf. DO NOT CREDIT air eg <ul style="list-style-type: none"> ● salt concentration – affects osmosis / water potential / enzymes ● removal of waste gases (CO₂) – reduce pressure / prevents explosion of fermenter ● speed of stirrer – ensure even , mixing / temperature
Total				14	

Question		Expected Answer	Mark	Additional Guidance
5	(a)	<p>A DNA polymerase / <u>Tag</u> polymerase ;</p> <p>B restriction endonuclease ;</p> <p>C (DNA) ligase ;</p> <p>D plasmid(s) ;</p> <p>E reverse transcriptase ;</p>	5	<p>Mark the first answer on each prompt line. If an additional answer is given that is incorrect or contradicts the correct answer, then = 0 marks</p> <p>B ACCEPT restriction enzyme or named example DO NOT ACCEPT restriction endonucleus</p>
5	(b)	<p>1 <i>hospital</i> WBCs , easy to obtain / obtained from blood sample ;</p> <p>2 WBCs good source of DNA ;</p> <p>3 mutant gene's location unknown / need to look in whole genome ;</p> <p><i>biotechnology company</i></p> <p>4 <i>idea that</i> insulin made in pancreas ;</p> <p>5 many <u>mRNA</u> copies there / <u>mRNA</u> easier to find ;</p> <p>6 AVP ;</p>	4 max	<p>1 ACCEPT <i>idea that</i> these cells less , painful / expensive / dangerous , to obtain</p> <p>2</p> <p>3</p> <p>4</p> <p>5</p> <p>6 eg • introns already removed in mRNA</p>

Question	Expected Answer	Mark	Additional Guidance
<p>5 (c)</p> <p><i>contd</i></p>	<p><i>advantages of PCR</i></p> <p>A1 PCR quicker ; E1 explanation ;</p> <p>A2 PCR uses less equipment ; E2 explanation ;</p> <p>A3 PCR uses less space ; E3 explanation ;</p> <p>A4 PCR less labour-intensive / easier / (some parts of process) less costly ; E4 explanation ;</p> <p>A5 PCR combines selection of gene and amplification but in vivo requires separate steps ; E5 explanation ;</p>		<p>For A marks points must be comparative - need to either match the 2 processes and state the advantage (eg PCR is quick and in vivo is slow) or use a comparative adjective (-----er, less, more, least, most, better, best etc) as shown in the mark scheme.</p> <p>For the related E mark, accept any explanation that is true of one of the processes <i>and relates to the advantage described</i>. (Note that in some cases a statement could be considered as an advantage or as an explanation.)</p> <p>A1</p> <p>E1 eg</p> <ul style="list-style-type: none"> ● few hours versus weeks ● 30 cycles ● no bacterial growth or screening stages <p>A2</p> <p>E2 eg</p> <ul style="list-style-type: none"> ● tube and heat block for PCR ● multiple test tubes or agar plates for in vivo <p>A3</p> <p>E3 eg</p> <ul style="list-style-type: none"> ● DNA and enzyme more compact than whole cells ● no growth medium required ● in vivo requires many plates to be , stored / incubated / refrigerated <p>A4</p> <p>E4 eg</p> <ul style="list-style-type: none"> ● PCR set to run and left ● in PCR gene is identified & cloned in one stage ● in vivo requires work to pick out and transfer colonies ● in vivo requires more purification of DNA at end <p>A5</p> <p>E5 eg</p> <ul style="list-style-type: none"> ● primer selects only correct gene to be copied ● in vivo needs probe to identify correct gene

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5	(c)	<i>contd</i>	A6 E6	PCR safer ; explanation ;	7 max	A6 E6	eg <ul style="list-style-type: none"> • PCR uses DNA and enzymes • PCR does not use whole cells which could cause contamination
			A7 E7	PCR can use lower quality DNA ; explanation ;		A7 E7	eg <ul style="list-style-type: none"> • can use , old / prehistoric / forensic , DNA
			A8 E8	<i>advantages of in vivo</i> in vivo less prone to mutation ; explanation ;		A8 E8	eg <ul style="list-style-type: none"> • Taq polymerase occasionally inserts wrong base • early mutation reproduced many times in PCR • exact correct sequence needed for making therapeutic proteins
			A9 E9	in vivo less expensive ; explanation ;		A9 E9	eg <ul style="list-style-type: none"> • materials for growing bacteria cheap • PCR chemicals / primers / Taq polymerase / high temperatures , expensive
			A10 E10	in vivo less technically complex ; explanation ;		A10 E10	eg <ul style="list-style-type: none"> • conditions not so critical • optimising PCR takes time
			A11 E11	in vivo useful , when gene less well known / as longer piece of DNA can be cloned ; explanation ;		A11 E11	eg <ul style="list-style-type: none"> • searching for new gene • obtains complete gene • PCR has limited size (for cloning)
			QWC – clearly stated advantage linked to correct explanation ;		1	2 pairs of A & E marks awarded. (eg A1 & E1 and A5 & E5 A9 & E9 and A4 & E4 etc)	
				Total	17		

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6	(a)			Mark the first answer on each prompt line for all parts of (a). If an additional answer is given that is incorrect or contradicts the correct answer, then = 0 ACCEPT phonetic spelling
6	(a)	(i) <u>tropism(s)</u> ;	1	IGNORE named tropism eg phototropism
6	(a)	(ii) (plant) hormone / growth substance / growth regulator / pgr ;	1	
6	(a)	(iii) <u>deciduous</u> ;	1	
6	(a)	(iv) <u>conservation</u> ;	1	DO NOT CREDIT preservation
6	(a)	(v) decomposer(s) ;	1	ACCEPT saprotroph / saprophyte / saprobiont IGNORE fungi / bacteria DO NOT CREDIT detritivore
6	(a)	(vi) nitrogen fixation ;	1	ACCEPT nitrogen fixing DO NOT CREDIT nitrogen fixing bacteria
6	(b)	(i) stimulus identified ; organism named and normal response described ; response , stops / lessens , after repeated stimulation / over time ;	3	eg • touch eg • sea anemone withdrawing tentacles 'learning to ignore' is not quite enough
6	(b)	(ii) organism named and voluntary behaviour described ; reinforcer / reward / punishment , identified ; behaviour , increases (for reward) / decreases (for punishment) , in frequency ;	3	eg • dog begging eg • food reward / treat

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6	(b)	(iii)	<p>primate species identified ;</p> <p>behaviour described ;</p> <p>purpose / importance , stated ;</p>	3	<p>Marks can be awarded in general context of social interaction instead of a specific piece of behaviour described.</p> <p>CREDIT English names eg chimpanzee, gorilla, orang-utan, (named) monkey, lemur or ape</p> <p>IGNORE humans</p> <p>eg</p> <ul style="list-style-type: none"> ● include dominance hierarchy interactions (play, aggressive, affiliative) ● allogrooming ● communication behaviours (vocal, facial, postural) ● passing on of , cultural / tool-using, knowledge ● <i>idea of</i> prolonged / frequent , mother-infant interactions <p>CREDIT answers relating to benefit to group or to individual</p> <p>eg ● with respect to access to food, resources or mates</p> <p>eg ● reducing , disease / parasites</p>
Total				15	