Question			Answer	Marks	Guidance
1	(a)		reduce / slow, flow rate ; repeat process / run milk through again ; test for (named) sugars in milk ;	2	**ACCEPT** close tap for a time period **CREDIT** glucose, galactose, lactose, Benedict's test
	(b)	(i)	*any two from* hydrophobic / ionic bond, to (named), solid / support ; covalent bond / cross-link to**,** (named) substance**;** membrane separation ; (en)trap / encapsulate / suspend, in (named), matrix ;	2	**Mark as prose.** **IGNORE** ref to cross-linking agents **ACCEPT** 'insoluble material for solid. Suitable solids = clay, carbon, resin, glass, gold, ceramic beads. **CREDIT** **ad**sorption (but not absorption) **CREDIT** carrier bound. **CREDIT** cross-link them together. Suitable substances = other enzymes, collagen, cellulose. **ACCEPT** microcapsules Suitable matrix materials = collagen, cellulose, silica gel, hydrogel, but **DO NOT CREDIT** entangled / alginate

		(ii)	1 (enzyme) can be re-used so reduces cost ;
			
			 2 product**,** pure(r) / uncontaminated ;
			
			 3 reduced downstream processing costs ;
			
			 4 (immobilised enzyme) works at high(er) temperature ;
			
			 5 (immobilised enzyme) works in changed pH ;
			
			 6 reaction, can be faster / have higher yield ,
			         because can be done at higher temperature ;
				4	
					
					 2 ACCEPT product not mixed with enzyme
					
					 3 ACCEPT save money on purifying product
					
					 4 CREDIT enzymes not denaturing at increased temperature
					     CREDIT immobilised enzymes thermostable
					
					 5 CREDIT enzymes not denaturing in changed pHs
					
					 6 This explanation scores mp 4 and mp 6 (unless mp 4 already awarded).

			Total	8	

	Question		Answer		Marks	Guidance
2	(a)	(i)	C ;		1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
		(ii)	D ;		1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
		(iii)	B / E ;		1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
		(iv)	E ;		1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
	(b)		1	muscles <u>contract</u>, in antagonistic (pairs) ;	3	**1 CREDIT** biceps and triceps **or** flexor and extensor contract **IGNORE** context of direction of movement
			2	tendons, pull on bone / connect muscle to bone ;		
			3	ligaments, hold bones together / prevent dislocation ;		
			4	cartilage, reduces**,** friction / wear ;		**4 ACCEPT** 'prevents' for reduces
			5	synovial membrane secretes fluid ;		**5 ACCEPT** makes, produces but not 'releases'
			6	<u>synovial</u> fluid, is a lubricant / allows smooth movement ;		**6 ACCEPT** prevents / reduces, friction

Question			Answer	Marks	Guidance
	(c)		**1** (two parts are) sympathetic **and** parasympathetic **;**	7	**1** If BOTH names are wrong but begin with **S and P, DO NOT CREDIT** mp1 but allow ECF for mps 2-12
			2 **S** has, short preganglionic neurone / long postganglionic neurone / ganglia near(er) spinal cord, **but P** has, long preganglionic neurone / short postganglionic neurone / ganglia near(er) organ **;**		**2** **ACCEPT** tissue for organ
			3 **S** uses noradrenaline **but P** uses acetylcholine (at organ) **;**		**3** **CREDIT** norepinephrine for noradrenaline but **IGNORE** noradrenaline from adrenal gland and **IGNORE** references to ganglion here
			4 **S,** fight / flight / stress, **but P**, rest / relaxation / calm **;**		
			5 **S** increases, heart rate / cardiac output / blood pressure, **but P** reduces this **;**		
			6 **S** increases , speed / rate / depth, of breathing, **but P** reduces this **;**		**6** **CREDIT** **S** increases ventilation rate and **P** slows it
			7 **S** increases airway diameter **but P** reduces it **;**		
			8 **S** increases blood flow to skeletal muscle **but P** increases blood flow to gut (smooth muscle) **;**		**8** **CREDIT** voluntary or striated for skeletal **IGNORE** ORA
			9 **S** for orgasm **but P** for sexual arousal **;**		
			10 **S** dilates pupils **but P** constricts pupils **;**		
			11 **S** makes liver release glucose, **but P** makes liver, store / take up, glucose **;**		**11** **ACCEPT** correct reverse reasoning for glycogen **IGNORE** sugar 'liver' must be mentioned at least once
			12 **P** allows**,** <u>peristalsis</u> / digestion, **but S** reduces it **;**		**12 IGNORE** 'stops' for **S** but allow **S** inhibits
			QWC ;	1	Award **QWC** if **1 mark** awarded for organisation mps **1-3** and **2 marks** awarded for functions mps **4-11**
			Total	15	

	Question		Answer	Marks	Guidance
3	(a)		metaphase **I and** metaphase **II ;** prophase **I ;** anaphase **II ;** telophase **II ;** anaphase **I ;**	5	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**

	(b)		to, **halve** chromosome number / **reduce from** 2n **to** n ;
			
			to separate homologous pairs (of chromosomes)
			                            and sister chromatids ;
			
			because, DNA (previously) replicated /
			       chromosomes are two chromatids at start ;
				2	**IGNORE** all references to mitosis
					
					CREDIT 'from diploid **to** haploid'
					ACCEPT 'from 46 **to** 23 chromosomes'
					IGNORE halve, genetic material / DNA
					
					ACCEPT genetic, material / information

	(c)	(i)	sequence / order, of bases / nucleotides ;	1	**CREDIT** base pairs **DO NOT CREDIT** amino acid sequence

		(ii)	different, primary / secondary / tertiary, structure ;
			
			(protein) shorter due to, deletion / stop codon **OR**
			                longer due to, insertion / duplication ;
			
			(protein) unchanged due to, silent mutation /
			                    non-coding DNA altered ;
			
			(function is) lost / worse / better ;
				3	**ACCEPT** different <u>sequence</u> or <u>order</u> of amino acids
					ACCEPT different 3D folding or 3D shape
					
					for 'silent' **CREDIT** 'neutral' or a description of more than one triplet coding for one amino acid
					
					IGNORE different / altered function
					ACCEPT idea that change is harmful

			Total	11	

Question			Answer	Marks	Guidance
4	(a)		<table><tr><td>biological principle</td><td>letter</td></tr><tr><td>artificial selection</td><td>E ;</td></tr><tr><td>predator-prey interaction</td><td>G ;</td></tr><tr><td>apical dominance</td><td>B ;</td></tr><tr><td>nitrogen fixation and nitrification</td><td>D ;</td></tr><tr><td>reproductive cloning</td><td>A / F ;</td></tr><tr><td>positive chemotaxis</td><td>H ;</td></tr><tr><td>decomposition</td><td>C / D ;</td></tr><tr><td>commercial use of plant hormones</td><td>F ;</td></tr></table>	8	**Award 1 mark per row.** **Mark the first answer in each box.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
	(b)		respiration / decomposition / decay / ripening **;** <u>interspecific competition</u> **;** (positive) <u>phototrop</u>ism **;** <u>succession</u> **;**	4	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ACCEPT** metabolism / metabolic reactions **DO NOT CREDIT** negative phototropism **DO NOT CREDIT** trophism (as ambiguous with trophic)

Question			Answer	Marks	Guidance
	(c)		*animals = primary consumers*	3	
			1 keep animals, warm / indoors **;**		
			2 reduce animal movement **;**		**2 ACCEPT** zero grazing idea
			3 feed animals high, protein / energy, food **;**		**3 ACCEPT** growth-enhancing food additives
			4 vaccination / (routine) antibiotics, for animals **;**		**4 IGNORE** hormones
			5 selective breeding / genetic engineering, for improved animals **;**		**5 ACCEPT** description of improvement, e.g. disease resistant, faster-growing, higher yielding
			6 slaughter just before, mature / full size **;**		
			Total	**15**	

	Question		Answer	Marks	Guidance
5	(a)	(i)	*idea of* tentative / uncertain / developing / advancing / improving / dynamic **;**	1	**IGNORE** change(s), changing, changeable (as given in question)
		(ii)	 **1** conservation / keep rare plants / save endangered plants **;** **2** <u>gene bank</u> **OR** genetic resource / store of alleles **;** **3** teaching / education **;** **4** leisure / amenity / visitor attraction / aesthetic value **;**	2	**Read as prose.** **1 ACCEPT** prevent extinction / maintain biodiversity **3 IGNORE** 'research' (as given in question)
	(b)	(i)	to**,** amplify / make (many) copies of**,** <u>DNA</u> **;** (range of) different lengths **;**	2	**IGNORE** refs. to single stranded / coding strand / template strand **CREDIT** idea of, chain terminating / dideoxy, nucleotides attaching at different points along sequence
		(ii)	to put DNA pieces in size order **;** to read, base sequence / order of bases **;**	2	**IGNORE** speed or rate of movement, look for distance or position or pattern, e.g. shortest / lightest / smallest**,** lengths first or lighter move further and heavier move less far **DO NOT CREDIT** 'put genome back in order'
		(iii)	to cut (genome DNA) into, small(er) / 750 bp, fragments **;** to cut, vectors / BACs / plasmids, (for gene library) **;**	2	**ACCEPT** fragment size in range 500-1000 base pairs

Question			Answer	Marks	Guidance
(c)			genome, too big / very large **;** accuracy better / fewer errors (with small fragments) **;** divide job over, time / different labs **;**	2	**ACCEPT ORA** only**,** small sections / 750bp, can be sequenced (at a time) **CREDIT ORA** large sections sequenced less accurately **ACCEPT** otherwise would take <u>too</u> long / be unmanageable / be impractical **IGNORE** ref to efficiency
(d)	**(i)**		1 160 000 **; ;**	2	**Correct answer = 2 marks (no units)** **CREDIT** 1.16 <u>million</u> **or** 1.16 x 10^6 If answer incorrect, **award 1 mark** for 870 (million) $\div$ 750 **AWARD** 1 max correct answer has inappropriate units (e.g. 1 160 000 Mbp = 1 mark)
	(ii)		 (monkey flower) has, small<u>er</u> genome / few<u>er</u> Mbp DNA **;** fewer lab hours / fewer staff needed / quicker / cheaper **;**	2	**Read as prose.** **ACCEPT ORA** but must be comparative **IGNORE** refs to chromosome number **ACCEPT ORA** but must be comparative
	(iii)		 larger (in size) **;**	1	 **ACCEPT** bigger **/** plumper / juicier

Question			Answer	Marks	Guidance
	(e)		*phylogenetic approach*	2	
			no need to test for interbreeding **;**		**ORA** for biological species concept – (importance of members of same species) (inter)breeding to give fertile offspring
			ref. common ancestor / <u>monophyletic</u> groups **;**		**IGNORE** clades
			can apply to organisms that reproduce asexually **;**		**ORA** for biological species concept – doesn't apply to asexually reproducing organisms
			can apply to, extinct organisms / fossils **;**		**ORA** for biological species concept – doesn't apply to, extinct organisms / fossils
			Total	**18**	

Question			Answer	Marks	Guidance
6	(a)	(i)	<table><tr><td></td><td>**Discontinuous**</td><td>**Continuous**</td></tr><tr><td>**Species identified by letter**</td><td>**S** and **T** ;</td><td>**R** ;</td></tr></table>	2	
		(ii)	statement **1** in **S and T only** ; statement **8** in **S and T only** ; statements **2 and 3** in **R only** ; statement **5** in **R only** ; statements **4 and 7** in **T only** ; statement **6** in **S only** ;	6	<table><tr><td>**Species**</td><td>**Statement number(s)**</td></tr><tr><td>**R**</td><td>2 3 5</td></tr><tr><td>**S**</td><td>1 6 8</td></tr><tr><td>**T**</td><td>1 4 7 8</td></tr></table>

Question			Answer	Marks	Guidance
	(b)		*collection* **1.** named equipment for collecting from, dogs / fields **;** **2.** get**,** large number / over 100 (fleas) **;** **3.** use several, dogs / fields **;** **4.** *idea of* random sampling (dogs / field) **;** *testing* **5.** (named) container **;** **6.** correct dose / range (of concentrations)**,** tested **;** **7.** control without flea killer **;** **8.** delivery method described **;** *processing* **9.** leave for set time **;** **10.** count number of, dead / live**,** fleas (after testing) **;** **11.** calculate percentage (frequency) of**,** alive / dead / resistant / non-resistant **;**	6	**1 CREDIT** pooter, forceps, tweezers, pipette, (flea) comb, sweep net, sticky traps, light traps (in correct context) **5 CREDIT** tank, jam jar, boiling tube, petri dish. **6 ACCEPT** 'dose according to manufacturer's instructions' **IGNORE** same, volume / concentration **8** e.g. flea-killer sprayed / left to evaporate from cotton wool / fed in blood or food **9 ACCEPT** leave for same amount of time **10 IGNORE** how many were left, how many were resistant **IGNORE** identify – must be counting number
			QWC ;	1	Award if the **first mark point awarded in each section** is *in the correct section order*: collection **1 to 4** **then** testing **5 to 8** **then** obtaining and processing results **9 to 11** *e.g. if the first mark of each section is awarded in the wrong order (such as mp 1, then mp 10, with nothing from the testing section inbetween)* **then do not award QWC**
			Total	**15**	

	Question		Answer	Marks	Guidance
7	**(a)**	**(i)**		2	**Mark the first 2 reasons**
			(both) to, avoid / counter, (abiotic) stress **;**		**CREDIT** to avoid named stressors e.g. cold, heat, dryness, humidity or unfavourable conditions **only CREDIT** descriptions relevant to both animals (avoiding a stressor) **and** to plants (closing stomata, wintering underground, etc). **IGNORE** survival and dangers unqualified
			(both) to avoid, being eaten / predation **;**		**only CREDIT** descriptions relevant to both animals (being consumed, being preyed upon) **and** to plants (being grazed, herbivory).
			(both) to access resources **;**		**only CREDIT** descriptions relevant to both animals (get food) **and** plants (obtain light, minerals, water)

		(ii)	*all points must show a clear comparison between mammals (M) and plants (P)*
			
			1 (M) made in <u>endocrine</u> glands **versus**
			            (P) made in many plant tissues **;**
			
			2 (M) move in blood **versus**
			   (P) move, in xylem / in phloem / from cell to cell **;**
			
			3 (M) act on**,** a few / specific / target, tissues **versus**
			  (P) act on most tissues / can act in cells where produced **;**
			
			4 (M) act <u>more</u> rapidly **; ORA**
				3	
					
					2(P) ACCEPT diffusion / through plasmodesmata, for 'from cell to cell'.
					      ACCEPT by translocation / in transpiration stream
					      IGNORE mass flow
					
					4 must be comparative e.g. respond fast**er** in mammals

	(b)	**(i)**	inherited / passed to offspring / passed (down) from parents **;** (caused by) <u>mutation</u> / <u>allele</u> **;**	2	**ACCEPT** in context of condition or gene

Question			Answer	Marks	Guidance
		(ii)		5	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
			<u>gene</u> / <u>allele</u> **;**		
			(DNA) <u>ligase</u> **;**		
			transgenic / transformed **;**		**ACCEPT** recombinant / GE / GM
			antibiotic(s) **;**		**CREDIT** named antibiotic e.g. ampicillin, tetracycline
			(gene / DNA / fluorescent / radioactive) <u>probe</u> **;**		
	(c)		fat soluble / non-polar / uncharged / hydrophobic **;**	2	
			(so can move directly through) phospholipid bilayer **;**		**ACCEPT** through phospholipi<u>ds</u> / through phospholipid membrane **DO NOT CREDIT** through pores

Question			Answer	Marks	Guidance
	(d)		**EITHER**	4	**Mark the first example.**
			1 *(lac)* <u>repressor protein</u> ;		
			2 (repressor protein) changes shape when bound to lactose ;		
			3 (with lactose) lifts off <u>operator</u> allowing, transcription / gene expression / binding of RNA polymerase to promoter ; **ORA**		**3 ORA** without lactose the protein binds to the <u>operator</u> stopping, transcription / gene expression / binding of RNA polymerase to promoter **DO NOT CREDIT** mp 3 if ref. made to DNA polymerase or DNA replication
			4 β-galactosidase / enzyme(s) / structural gene(s) ;		**4 CREDIT** lactose permease
			OR		
			5 homeotic / homeobox / hox (genes) ;		
			6 gene product / protein / transcription factor, binds to DNA ;		**6 CREDIT** homeobox domain / homeodomain, binds to DNA
			7 gene product / protein, starts transcription / is a transcription factor ;		**7 ACCEPT** controls **/** regulates **/** stops, transcription
			8 many genes affected / controls body plan ;		**8 CREDIT** controls, development / segmentation
			Total	18	