Question			Expected Answers	Marks	Additional Guidance
1	(a)	(i)	DNA / gene / genetic **,** fingerprinting / profiling / analysis **;** DNA / protein / gene **,** sequencing **;** electrophoresis **;**	**1 max**	**IGNORE** gene testing / gene probing / gene mapping / genome sequencing
1	(a)	(ii)	rarely / do not **,** produce seed / cross-pollinate / interbreed **;** only reproduce asexually **;**	**1 max**	
1	(a)	(iii)	vegetative propagation **;**	**1**	**IGNORE** asexual reproduction (as given in the question)
1	(b)		**1** genetically identical / little genetic variation **;** **2** all susceptible / none resistant **,** to this disease **;** **3** beetles **,** move / fly **,** from tree to tree **or** beetles are vector **;** **4** trees grow **,** in clonal patch / close together **or** disease spreads through **,** suckers / roots **or** connected by **,** suckers / roots **;** **5** the beetles only **,** live on / target **,** elm trees **;** **6** attempts at control contributed to spread **;** **7** as **more** trees became diseased then **more** tree surgery was necessary (contributing to spread of problem) **;** **8** as **more** trees became infected then **more ,** saws / equipment **,** were contaminated **;**	**4 max**	**1** **IGNORE** clone **2** **IGNORE** all susceptible to 'disease' in general. Only credit if **one particular** disease is implied e.g. the / new / fungus / same **,** disease **DO NOT CREDIT** immune instead of resistant **3** **IGNORE** simple repetition of text 'beetles spread disease'

Question			Expected Answers	Marks	Additional Guidance
1	(c)	(i)	**1** less / no **,** movement of water **or** less / no **,** water reaches leaves **;** **2** less / no **,** minerals / nitrate / phosphate / magnesium / iron **;** **3** less / no **,** chlorophyll formation **;** **4** chlorophyll breakdown / leaf senescence **;**	**2 max**	**2** **CREDIT** correct symbols NO_3^-, PO_4^{2-}, Mg^{2+}, Fe^{2+}, Fe^{3+} **IGNORE** nutrients **IGNORE** reference to other substances such as sugars
1	(c)	(ii)	**1** less / no **,** photosynthesis **;** **2** less / no **,** sugar(s) / amino acid(s) / assimilates / organic molecules **;** **3** <u>roots</u> cannot **,** respire / do active transport / metabolise **;** **4** the falling leaves carry the fungus **;**	**2 max**	**2** **CREDIT** named sugars, e.g. sucrose **,** glucose **,** hexose **IGNORE** nutrients / food

Question			Expected Answers	Marks	Additional Guidance
1	(d)	1	cut plant material into **,** explants / small pieces **;**		1 **DO NOT CREDIT** a single cutting
		2	example of part of plant used e.g. leaf / stem / root / bud / meristem / dividing region at tip of plant **;**		
		3	sterilise explant **;**		
		4	(with) bleach / sodium hypochlorite / alcohol **;**		
		5	place on **,** agar / growth medium **;**		5 **CREDIT** place in aerated solution
		6	containing **,** glucose / amino acids / nitrates / phosphates **;**		6 **IGNORE** polymers / carbohydrates
		7	callus **or** mass of **,** undifferentiated / totipotent **,** cells **;**		7 **DO NOT CREDIT** description of single cell
		8	high auxin **and** cytokinin (for callus formation) **;**		
		9	subdivide callus / sub-culturing **;**		9 **IGNORE** ref. single cells
		10	treat to induce **,** roots / shoots **;**		
		11	change plant hormone ratio **;**		11 **CREDIT** description **,** e.g. high auxin to give roots or (relatively) high cytokinin to give shoots (auxin : cytokinin ratio = 100 : 1 for roots, 4 : 1 for shoots, or similar figures)
		12	transfer to **,** greenhouse / soil / less controlled environment / non-sterile environment **;**		
		13	ref. aseptic conditions (anywhere within stages 5-11) **;**	**6 max**	**13** Do not award for sterilising explant (which is mp3)
			QWC – described in logical sequence of steps ;	**1**	**Award QWC for sequence of marks as follows:** either mp 1 or 2 **then** 1 mark from mps 5 – 8 **then** 1 mark from mp 9 - 12

Question			Expected Answers	Marks	Additional Guidance
1	(e)				**CREDIT** the first answer on each prompt line
			advantages		
			1 quick **;**		**1 IGNORE** ref. large numbers alone
			2 disease-free / virus-free **,** stock created **;**		
			3 plants have same feature / uniform plants created **;**		**3** refers to plant phenotype e.g. plants **,** grow at same rate / grow to same height
			4 can reproduce infertile plants **;**		
			5 can reproduce plants that are hard to grow from seed **;**		
			6 create whole plants from GM cells **;**		
			7 production **,** not determined by seasons / at any time / anywhere in the world **;**		
			8 (plantlets small) can be transported easily / grown in small space **;**		
			9 can save rare species from extinction **;**		
			disadvantages		
			10 expensive / labour intensive **,** process **;**		
			11 process can fail due to microbial contamination **;**		
			12 all offspring susceptible to *same* **,** pest / disease / named environmental factor (e.g. drought) **;**		**12 IGNORE** all are susceptible to disease in general (as in 3b)
			13 no / low / little **,** genetic variation **;**	**4**	**13 IGNORE** loss of alleles
				22	

Question			Expected Answer	Mark	Additional Guidance
2	(a)		**A** DNA polymerase / Taq polymerase **;** **B** restriction endonuclease **;** **C** (DNA) ligase **;** **D** plasmid(s) **;** **E** reverse transcriptase **;**	**5**	**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** ***B*** **ACCEPT** restriction enzyme or named example **DO NOT ACCEPT** restriction endonucleus
2	(b)		*hospital* **1** WBCs **,** easy to obtain / obtained from blood sample **;** **2** WBCs good source of DNA **;** **3** mutant gene's location unknown / need to look in whole genome **;** *biotechnology company* **4** *idea that* insulin made in pancreas **;** **5** many mRNA copies there / mRNA easier to find **;** **6** AVP **;**	**4 max**	***1*** **ACCEPT** *idea that* these cells less **,** painful / expensive / dangerous **,** to obtain ***2*** ***3*** ***4*** ***5*** ***6*** eg ● introns already removed in mRNA

Question			Expected Answer		Mark	Additional Guidance		
2	(c)					**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. **For the related E mark,** accept any explanation that is true of **one** of the processes *and relates to the advantage described*. (Note that in some cases a statement could be considered as an advantage or as an explanation.)		
				advantages of PCR				
			A1	PCR quick**er ;**		***A1***		
			E1	explanation **;**		***E1***	eg	● few hours versus weeks ● 30 cycles ● no bacterial growth or screening stages
			A2	PCR uses **less** equipment **;**		***A2***		
			E2	explanation **;**		***E2***	eg	● tube and heat block for PCR ● multiple test tubes or agar plates for in vivo
			A3	PCR uses **less** space **;**		***A3***		
			E3	explanation **;**		***E3***	eg	● DNA and enzyme more compact than whole cells ● no growth medium required ● in vivo requires many plates to be **,** stored / incubated / refrigerated
			A4	PCR **less** labour-intensive / easi**er** / (some parts of process) **less** costly **;**		***A4***		
			E4	explanation **;**		***E4***	eg	● 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
			A5	PCR combines selection of gene and amplification **but** in vivo requires separate steps **;**		***A5***		
			E5	explanation **;**		***E5***	eg	● primer selects only correct gene to be copied ● in vivo needs probe to identify correct gene
		contd						

Question			Expected Answer		Mark	Additional Guidance
2	(c)	*contd*	**A6** **E6**	PCR saf**er ;** explanation **;**		***A6*** ***E6*** eg ● PCR uses DNA and enzymes ● PCR does not use whole cells which could cause contamination
			A7 **E7**	PCR can use low**er** quality DNA **;** explanation **;**		***A7*** ***E7*** eg ● can use **,** old / prehistoric / forensic **,** DNA
				advantages of in vivo		
			A8 **E8**	in vivo **less** prone to mutation **;** explanation **;**		***A8*** ***E8*** eg ● 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 ● materials for growing bacteria cheap ● PCR chemicals / primers / Taq polymerase / high temperatures **,** expensive
			A10 **E10**	in vivo **less** technically complex **;** explanation **;**		***A10*** eg ● conditions not so critical ***E10*** ● optimising PCR takes time
			A11 **E11**	in vivo useful **,** when gene **less** well known / as longer piece of DNA can be cloned **;** explanation **;**	**7 max**	***A11*** ***E11*** eg ● 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**	

Question			Expected Answer	Mark	Additional Guidance
3	(a)		(belong to the) same genus ;	1	
3	(b)	(i)	**1** not much / little / some , competition / niche overlap ;		**This mark is for a stand alone statement** **DO NOT CREDIT no** competition **IGNORE** competition unqualified / inter / intra
			reasons for little competition **2** use / feed on , different sized flowers / different depth of flowers ;		**2** **CREDIT** correct comparative description or use of data e.g. *B. pratorum feed* on , bigger / longer / deeper , flowers **or** *B. pratorum* 7.4(mm) **and** *B. terrestris* 6.3(mm)
			3 vary in proportions of pollen **and** nectar they collect ;		**3** **CREDIT** correct description e.g. *B. pratorum* mostly pollen and nectar **and** *B. terrestris* mostly nectar only **or** comparison of 2 species using table data **IGNORE** 'different amounts' of pollen and nectar
			4 fly / live / active / feed / visit flowers , at different times ;		**4** **CREDIT** correct description of difference e.g. *B. pratorum* peak in June **and** *B. terrestris* in July **or** *B. pratorum* appear in earlier in the year **or** comparison of 2 species using graph data
			reason for competition **5** *idea that* fly / live / active / feed / visit flowers , overlaps there must be competition ;		**5** **CREDIT** correct description from data e.g. both compete for food between May and September / both collect pollen only from same % flowers
			6 AVP ;	4 max	**6** e.g. use / feed on , different species of flowers

Question			Expected Answer	Mark	Additional Guidance
3	(b)	(ii)	**1** *idea of* isolation / isolating mechanism / barrier **;**		
			2 seasonal (difference) / temporal (difference) / males and queens (in different populations) produced in different months / breeding (in different populations) in different months **;**		**2** **CREDIT** example of seasonal / temporal (e.g. *B. pratorum* has its peak number of workers in June and *B. terrestris* in July)
			3 behavioural (difference) / visit different (types of) flowers / feed at different times / feed on different food types **;**		**3** **CREDIT** 'different mating rituals'
			4 different flower locations / different (micro)habitats **;**		
			5 *idea that* gene flow restricted / no gene flow (between populations) **;**		**5** **must refer to gene /allele**
			6 different adaptations / specialisation / niche partitioning **;**	**3 max**	**6** **IGNORE** speciation (as implied in Q) - can be mistaken for specialisation

<table>
<tr><th colspan="3">Question</th><th>Expected Answer</th><th>Mark</th><th>Additional Guidance</th></tr>
<tr><td>3</td><td>(c)</td><td>(i)</td><td>
<table>
<tr><th>Observation</th><th>Type of behaviour</th></tr>
<tr><td>The time taken for a worker bee to collect food from a flower decreases with practice.</td><td>learned (behaviour) / learning /
operant conditioning / trial and error ;</td></tr>
<tr><td>All bumble bees start at the bottom of a vertical spike of flowers and work upwards.</td><td>innate / instinctive ;</td></tr>
</table>
</td><td>2</td><td>Mark the first answer in each box. If an additional answer is given that is incorrect or contradicts the correct answer, then = 0 marks

ACCEPT taxis / example of taxis eg chemotaxis
IGNORE inherited / genetically determined
DO NOT CREDIT kinesis</td></tr>
<tr><td>3</td><td>(c)</td><td>(ii)</td><td>Idea that better / more efficient , at , finding / getting , food ;

AVP ;</td><td>1 max</td><td>ACCEPT more food can be collected
less , time / energy , spent looking for food
easier to find food
e.g. ref to reduces competition from other colonies</td></tr>
<tr><td>3</td><td>(d)</td><td>(i)</td><td>reverse transcriptase ;</td><td>1</td><td>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

DO NOT CREDIT DNA (reverse) transcriptase</td></tr>
</table>

Question			Expected Answer	Mark	Additional Guidance
3	(d)	(ii)	**1** <u>mRNA</u> binds to **,** (gene) probes / cDNA / ssDNA **,** by complementary base pairing **;** **2** *idea that* the ***more*** active the gene the ***more*** mRNA produced **;** **3** during transcription **;** **4** ***more*** fluorescence indicates ***more*** mRNA (bound) **;**	**3 max**	**1** **DO NOT CREDIT** in the context of the gene probe binding to DNA **3** **IGNORE** translation
3	(d)	(iii)	**1** dopamine linked to **,** ADHD / addiction / risk-taking / adventurous behaviour / hyperactivity / erratic behaviour (in humans) **;** **2** *idea of* common mechanism in bees and humans (for adventurous behaviour) **;** **3** *idea that* as they are different organisms the mechanisms may not be comparable (even though apparently similar) **;** **4** AVP **;**	**3 max**	**1** **IGNORE** ref to schizophrenia / Parkinson's **This mark is for the effect of the *chemical* dopamine, not the dopamine receptors alone.** **2** e.g. ***both*** have **,** DRD4 / dopamine receptors e.g. dopamine has the same effect in ***both*** **4** e.g. other genes also involved in **,** bee / human **,** behaviour **Note:** 'both have dopamine receptors which are linked to adventurous behaviour' **= 1 mark** (mp 2 only) 'both have dopamine receptors and dopamine is linked to adventurous behaviour' **= 2 marks** (mps 2 & 1)
			Total	**18**	

Question			Answer	Marks	Guidance
4	(a)	(i)	(both) to, avoid / counter, (abiotic) stress **;**	2	**Mark the first 2 reasons** **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 endocrine 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 more 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) mutation / allele **;**	2	**ACCEPT** in context of condition or gene

Question			Answer	Marks	Guidance
		(ii)	gene / allele **;** (DNA) ligase **;** transgenic / transformed **;** antibiotic(s) **;** (gene / DNA / fluorescent / radioactive) probe **;**	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** **ACCEPT** recombinant / GE / GM **CREDIT** named antibiotic e.g. ampicillin, tetracycline
	(c)		fat soluble / non-polar / uncharged / hydrophobic **;** (so can move directly through) phospholipid bilayer **;**	2	**ACCEPT** through phospholipids / through phospholipid membrane **DO NOT CREDIT** through pores

Question			Answer	Marks	Guidance
	(d)		**EITHER** **1** *(lac)* repressor protein **;** **2** (repressor protein) changes shape when bound to lactose **;** **3** (with lactose) lifts off operator allowing, transcription / gene expression / binding of RNA polymerase to promoter **; ORA** **4** β-galactosidase / enzyme(s) / structural gene(s) **;** **OR** **5** homeotic / homeobox / hox (genes) **;** **6** gene product / protein / transcription factor**,** binds to DNA **;** **7** gene product / protein**,** starts transcription / is a transcription factor **;** **8** many genes affected / controls body plan **;**	4	**Mark the first example.** **3 ORA** without lactose the protein binds to the operator 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 CREDIT** lactose permease **6 CREDIT** homeobox domain / homeodomain, binds to DNA **7 ACCEPT** controls **/** regulates **/** stops**,** transcription **8 CREDIT** controls**,** development / segmentation
			Total	**18**	