

Question			Expected Answer	Mark	Additional Guidance
1	(a)	(i)	microbes / (living) organisms / cells / enzymes ; (make) product / for human benefit / (carry out) conversion / reaction / industrial process ;	2	CREDIT microorganisms / bacteria / prokaryotes / fungi CREDIT living things CREDIT cell components / parts of cells CREDIT example such as (named) food or medicine BUT IGNORE cheese (as stated in question) IGNORE process unqualified
1	(a)	(ii)	microbes / AW , killed / removed / not present ; enzymes <u>denatured</u> ; (so no) competitors / unwanted reactions / (human) health risk ;	2 max	Mark the first two suggestions IGNORE contamination / sterile IGNORE idea of preserving milk AW for microbes as in (a)(i) plus ACCEPT organisms DO NOT CREDIT microbes denatured CREDIT (no) competition CREDIT (no) food spoilage / change of flavour / loss of quality CREDIT (no) pathogens / harmful microbes / TB “Kills harmful microbes” or “Kills pathogens” scores 2 marks (mps 1 & 3)

Question			Expected Answer	Mark	Additional Guidance
1	(b)	(i)	<p>1 enzyme ;</p> <p><i>plus any 2 of the following</i></p> <p>2 (enzyme) not, changed / used up ; ora</p> <p>3 <i>idea of ESC (forms) / substrate and enzyme (bind) ;</i></p> <p>4 products (and enzyme) released at end ;</p>	<p>1</p> <p>max 2</p>	<p>Award mp 1 plus 2 max from the other mark points</p> <p>1 ACCEPT globular / tertiary / catalyst / catalytic (protein)</p> <p>2 ora = can be used again / re-used IGNORE enzyme recycled</p> <p>3 ESC = enzyme-substrate complex ACCEPT substrate entering active site</p>
1	(b)	(ii)	<p>1 (enzyme can be removed to be) used again ;</p> <p>2 (enzyme can) to leave pure(r) product ; ora</p> <p>3 (enzyme) more stable / more efficient / works better ;</p>	<p>2</p>	<p>Mark the FIRST suggestion on each numbered line IGNORE 'cheaper' without qualification</p> <p>2 ACCEPT cheaper / easier, downstream processing</p> <p>3 CREDIT less susceptible to, pH / temperature, change / extremes “enzymes work at high temperatures” = 0 “enzymes work at higher temperatures” = 1 (because comparative statement made)</p>

CHERRY HILL TUITION OCR BIOLOGY A2 PAPER 25 MARK SCHEME

Question	Expected Answer	Mark	Additional Guidance
<p>1 (c)</p>	<p><i>This is a QWC question</i> <i>Section I - Obtaining the gene</i> 1 use restriction, enzyme / endonuclease ; 2 to, cut out / get / isolate, (rennin) gene / DNA coding for rennin or to, fragment / digest, DNA ; 3 <u>gene</u> probe ; OR 4 obtain rennin mRNA ; 5 (use) reverse transcriptase ; 6 to make cDNA ; OR 7 sequence, rennin (protein) ; 8 work out base code ; 9 make this DNA sequence ; 10 sticky ends ; <i>Section II - Vector</i> 11 cut (open), plasmid / phage ; 12 using same <u>restriction</u> enzyme ; 13 annealing / base pairing of sticky ends ; 14 join sugar-phosphate backbones ; 15 (using DNA) ligase ; 16 <u>recombinant</u>, vector / plasmid / phage / DNA ; <i>Section III - Introduction into host cell</i> 17 mix with bacteria ; 18 detail of conditions ; 19 <u>transformation</u> (plasmid) / <u>transduction</u> (phage) ;</p>	<p>max 7</p>	<p>1 CREDIT named example e.g. <i>Eco</i> R1, <i>Bam</i> H1, <i>Hin</i> dIII 2 DO NOT CREDIT 'cut gene' IGNORE 'break up DNA' NOTE 1-9 CREDIT whichever of the three alternative "obtaining the gene" protocols yields most marks, either award marking points 1-3 or 4-6 or 7-9 10 can be awarded, once only, in Sections I or II 11 DO NOT CREDIT 'cut out plasmid' DO NOT CREDIT 'ring of DNA' unless it is clear that plasmid is being referred to 12 CREDIT same named enzyme (re. mp1) 13 CREDIT idea of sticky end bases hydrogen bonding 14 CREDIT formation of phosphodiester bonds 18 e.g. Ca²⁺ ions added / heatshock (freeze then inc to 40°C) 19 CREDIT transform / transformed / transduce / transduced IGNORE transgenic</p>
	<p>QWC – sequencing of steps – at least 1 mark point scored from each of the three sections, in the correct order ;</p>	<p>1</p>	<p>I. obtaining gene (mp 1 – 9) followed by II. vector (mp 13 – 16) followed by III. introduction to host cell (mp 17 – 19)</p>
	<p>TOTAL</p>	<p>17</p>	

CHERRY HILL TUITION OCR BIOLOGY A2 PAPER 25 MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	red ; vermillion ; cinnabar ;	3	
2	(a)	(ii)	(recessive) epistasis / epistatic ;	1	ACCEPT complementary epistasis DO NOT CREDIT dominant epistasis
2	(a)	(iii)	<p>1 gene products are enzymes ;</p> <p>2 multi-enzyme / multi-step, pathway ;</p> <p>3 <u>3</u>, steps / enzymes, change tryptophan to red pigment ;</p> <p>4 product of one reaction / intermediate compound, is, substrate / starting point, for next ;</p> <p>5 dominant allele gives, functional / wild-type / AW, enzyme ;</p> <p>6 recessive allele gives, non-functional / different / AW, enzyme ;</p>	max 3	<p>2 needs to be a clear generalised statement (and not implied - e.g. by awarding mp 3)</p> <p>IGNORE 'metabolic' pathway (as given in question)</p> <p>3 ACCEPT V, C <u>and</u> B are responsible for the change of tryptophan to red</p>
2	(b)	(i)	<p>1 if (<i>red-eyed parent</i>) was heterozygous there would be no difference between, sexes / males and females ;</p> <p>2 red-eyed males and white-eyed females would occur ;</p> <p>1:1:1:1 ratio or 1:1 ratio in both sexes ;</p>	max 2	<p>IGNORE ref to sex linkage</p> <p>2 ACCEPT "because there are no red-eyed males and white-eyed females (in results)" "all 4 phenotypes would, occur / be represented" DO NOT infer phenotype(s) from genotype(s)</p> <p>3 If 4 phenotypes stated / listed <i>together with the ratio</i>, then award mp 2 as well</p>

Question			Expected Answers						Marks	Additional Guidance	
2	(b)	(ii)	parental genotypes	XrXr	XRY-	;			3	<p>ACCEPT alternative letters only if a KEY is given. Must have capital letter for dominant allele and small (same) letter for recessive allele.</p> <p>CREDIT GAMETES either on the correct line or in correct place on Punnett square, whichever is correct. They do not need to be in circles.</p> <p>ACCEPT ecf once only if Y wrongly shown as carrying 'r' allele</p> <p>ACCEPT ecf once only if X and Y missing</p> <p>DO NOT CREDIT F1 genotypes written in blank space if F1 phenotypes put on bottom lines instead</p>	
			gametes	Xr	XR and Y-	;					
			F1 genotypes	XRXr	XrY-	;					
2	(b)	(iii)	phenotype of fly	O	E	O - E	(O - E) ²	$\frac{(O - E)^2}{E}$	4	<p>One mark per row</p> <p>ACCEPT fractions in last column (4/25)</p> <p>ACCEPT not significant IGNORE ref to happening by chance</p> <p>ACCEPT ecf for last two points IGNORE arguments referring to null hypothesis</p>	
			red-eyed female	27	25	2	4	0.16			;
			white-eyed male	23	25	-2	4	0.16			;
			$\chi^2 = 0.32$; no significant difference (at 95% confidence level) ;								
Total								16			

CHERRY HILL TUITION OCR BIOLOGY A2 PAPER 25 MARK SCHEME

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3	(a)	(i)	<p>1 similar / same, cells / metabolism ;</p> <p>2 similar / same / share, <u>genes</u> or have <u>genes</u> in common ;</p> <p>3 similar / same, (embryonic) development ;</p> <p>4 shared, ancestry / ancestor or all related by evolution ;</p>	max 2	<p>1 ACCEPT they are all eukaryotic cells</p> <p>4 CREDIT due to phylogeny ACCEPT all same <u>kingdom</u> IGNORE 'they are all animals'</p>
3	(a)	(ii)	<p>1 small ;</p> <p>2 short life cycle ;</p> <p>3 easy to, keep / breed / AW ;</p> <p>4 cheap (to buy / keep) ;</p> <p>5 readily available / common / not rare ;</p> <p>6 large cells ;</p> <p>7 previously well-studied / many known mutants ;</p>	max 2	<p>Mark the FIRST answer on each numbered line</p> <p>2 ACCEPT fast development / mature quickly / fast reproductive rate / short generation time</p> <p>3 ACCEPT produce many offspring</p> <p>7 ACCEPT genome has been, mapped / sequenced</p>
3	(b)	(i)	<p>scanning ;</p> <p>electron (microscope) ;</p>	2	<p>CREDIT SEM = 2 marks ACCEPT transmission electron / TEM = 1 mark IGNORE micrograph</p>
3	(b)	(ii)	<p>description of legs in place of antennae in, mutant / 3.2 / AW ;</p>	1	<p>ACCEPT projections on head / antennae / feelers, <u>longer</u> (in Fig. 3.2)</p> <p>DO NOT CREDIT antennae / projections vs. none DO NOT CREDIT mandibles / fangs DO NOT CREDIT incorrect statement e.g. legs on mouth</p>
3	(b)	(iii)	<p>homeotic / homeobox / hox ;</p>	1	

CHERRY HILL TUITION OCR BIOLOGY A2 PAPER 25 MARK SCHEME

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<p>3 (c)</p>	<p>1 <i>synthesis</i> 2 DNA, copied into / →, mRNA or described ; 3 <u>transcription</u> / <u>transcribed</u> ; one strand copied ; 4 5 complementary base-pairing ; 6 triplet code / code read in threes / codon is 3 bases ; 7 base sequence determines amino acid sequence ; 8 <u>translation</u> ; 9 <u>ribosomes</u> ; role of tRNA described ; (max 6)</p> <p>10 <i>roles of polypeptides</i> 11 (named) structural protein ; enzymes / catalyse reactions / control metabolism ; 12 13 hormones / growth factors ; 14 receptor proteins ; adenylyl cyclase / cAMP ; 15 idea of switching genes, on / off ; 16 homeotic / homeobox, genes 17 or homeodomain proteins ; <i>idea of master switch gene /</i> one gene turns on/off whole set of other genes / cascades of gene switching ; 18 apoptosis ; (max 6)</p>	<p>7 max</p>	<p>MAX 6 marks for synthesis MAX 6 marks for roles</p> <p>1 DO NOT CREDIT descriptions that contain errors</p> <p>3 ACCEPT coding / sense / non-sense / template, strand (implying one only)</p> <p>4 CREDIT description of base pairing as correct to context</p> <p>9 e.g. “tRNA brings amino acid” or “tRNA anticodon binds to mRNA codon”</p> <p>10 e.g. actin / myosin / collagen / keratin</p> <p>12 CREDIT growth hormone / GH / somatotrophin / FSH</p> <p>14 most likely to be expressed in context of mp 12</p> <p>15 CREDIT transcription factors / regulatory proteins / repressor proteins</p>
	<p>QWC – balanced account ;</p>	<p>1</p>	<p>At least 2 marks from points 1 - 9 and at least 2 marks from points 10 – 18</p>
	<p>Total</p>	<p>16</p>	

Question		Expected Answers		Marks	Additional Guidance									
4	(a)		<table border="1"> <thead> <tr> <th></th> <th>similarity</th> <th>difference</th> </tr> </thead> <tbody> <tr> <td>structure</td> <td>mitochondria or vesicles or postsynaptic receptors ;</td> <td>NMJ membrane(s), wavy / AW * ora or receptors different (shape) or enzymes in different places ;</td> </tr> <tr> <td>function</td> <td>(neuro)transmitter, released / crosses gap or changes potential difference / AW ** or enzymes break down (neuro)transmitter ;</td> <td>different neurotransmitters / ACh vs. dopamine or muscle contraction vs. nerve impulse or different enzymes ;</td> </tr> </tbody> </table>		similarity	difference	structure	mitochondria or vesicles or postsynaptic receptors ;	NMJ membrane(s), wavy / AW * ora or receptors different (shape) or enzymes in different places ;	function	(neuro)transmitter, released / crosses gap or changes potential difference / AW ** or enzymes break down (neuro)transmitter ;	different neurotransmitters / ACh vs. dopamine or muscle contraction vs. nerve impulse or different enzymes ;	4	<p>One mark per box</p> <p><i>difference</i> NMJ is neuromuscular junction * AW ACCEPT wiggly / bumpy / not smooth / rough / larger SA / any suitable description but IGNORE microvilli</p> <p><i>difference</i> ACh is acetylcholine</p> <p><i>similarity</i> ** AW CREDIT depolarises / -70 mV → +40 mV but IGNORE pass on action potential</p>
			similarity	difference										
structure	mitochondria or vesicles or postsynaptic receptors ;	NMJ membrane(s), wavy / AW * ora or receptors different (shape) or enzymes in different places ;												
function	(neuro)transmitter, released / crosses gap or changes potential difference / AW ** or enzymes break down (neuro)transmitter ;	different neurotransmitters / ACh vs. dopamine or muscle contraction vs. nerve impulse or different enzymes ;												
4	(b) (i)	<p>1 phenelzine ;</p> <p>no ecf from incorrect drug</p> <p>2 <i>idea that</i> does not bind to (dopamine) receptor ; ora</p> <p>3 <i>idea that</i> binds to, MAO / enzyme ;</p> <p>4 allosteric site / non-competitive inhibitor ;</p>	1	<p>Award mp1 and, if correct, any 1 from the remaining points</p> <p>2 CREDIT other two do bind to dopamine receptor</p> <p>3 IGNORE inhibits, MAO / enzyme (as given in the question)</p> <p>4 ACCEPT “not a competitive inhibitor”</p>										
4	(b) (ii)	(drug) occupies / blocks / binds to, (dopamine) receptors ; without causing, action potential / response ; reduces effect of dopamine / is a dopamine antagonist ;	2	<p>CREDIT “without causing depolarisation” / AW DO NOT CREDIT “inhibits dopamine” or “reduces dopamine levels”</p>										

CHERRY HILL TUITION OCR BIOLOGY A2 PAPER 25 MARK SCHEME

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4	(c)	(i)	humans are, diploid / 2n ; chromosomes, are in pairs / homologous ; one, (copy / gene / allele), from each parent / on each chromosome of pair ;	2 max	DO NOT CREDIT ref to bivalents
4	(c)	(ii)	(gel) <u>electrophoresis</u> ;	1	
4	(d)	1	13 b-p deletion (has most serious consequences) ;	3 max	6 CREDIT could be a silent mutation / 1 b-p substitution may not have an effect
		2	frameshift / alter reading frame ;		
		3	genetic code is triplet / read in groups of 3 bases ;		
		4	alters all amino acids (coded for) after the mutation ;		
		5	21 b-p deletion causes 7 amino acids to be lost ;		
		6	substitution changes, one / no, amino acids ;		
4	(e)	1	<u>natural selection</u> ;	4 max	3 CREDIT increases reproductive success / AW 4 ACCEPT more promiscuous / AW 6 MUST HAVE time element
		2	<u>selective advantage</u> ;		
		3	(allele / behaviour) increases, survival / breeding / AW ;		
		4	(because) helped, find food / find new resources / make new tools / get mates ;		
		5	<u>allele</u> passed on (to next generation) ;		
		6	(allele / behaviour) increased in frequency over, generations / time ;		
Total				18	

Question		Expected Answers	Marks	Additional Guidance
5	(a)	ecosystem ; producers / autotrophs ; primary ; trophic level(s) ; biotic / living ; minerals / elements ;	6	DO NOT CREDIT plants DO NOT CREDIT trophic CREDIT named, element / ion, e.g. nitrogen, nitrate ACCEPT symbol e.g. N / NO ₃ ⁻ ACCEPT nutrient DO NOT CREDIT energy / waste products
5	(b)	(i) 1 limiting / density-dependent, factors ; 2 <u>carrying capacity</u> ; 3 intraspecific competition ; 4 for, food / nesting sites ; 5 interspecific competition ; 6 with, deer / tree shrew / giant squirrel ; <i>larger squirrel populations</i> 7 attract more predators ; 8 parasites / diseases, spread more easily ;	max 4	3 ACCEPT description e.g. • “competition with other members of the same species” • “competition with other (small) squirrels” 4 ACCEPT they run out of food 5 ACCEPT description e.g. “competition with other species” 7 DO NOT CREDIT predation alone, must be linked to larger squirrel population 8 DO NOT CREDIT disease alone, must be linked to larger squirrel population

CHERRY HILL TUITION OCR BIOLOGY A2 PAPER 25 MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
5	(b)	(ii)	species richness & evenness decrease ; ora (richness) 29 → 26 (species) ; (evenness) large numbers of, 2 / some, species, but, low numbers / none, of other species ;	max 2	ACCEPT they both, decrease / decline / fall or they were higher at start ACCEPT 6 → 4 or 2 fewer (from table) or 3 fewer (from text) CREDIT suitable named e.g.s from table
5	(c)	(i)	rare initially / AW ; prey, numbers have reduced / have become extinct / have left the area ; idea of slower reproductive rate / AW ;	max 1	ACCEPT that there weren't very many at start DO NOT CREDIT 'lack of food' unless has indicated that food is an animal ACCEPT don't breed as fast / don't have as many offspring
5	(c)	(ii)	1 aesthetic / amenity / recreational, value ; 2 (eco)tourism ; 3 to, preserve biodiversity / preserve genetic diversity / stop extinction ; 4 ref. interactions between species / need to preserve whole habitat ; 5 (rainforest species / preserve gene pool as) could be useful, in future / as potential, for, medicine / genetic engineering / AW ; 6 to support indigenous peoples / AW ; 7 to stop effect of deforestation on, atmosphere / climate / soil ; 8 AVP ;	max 3	Mark the FIRST suggestion on each numbered line 1 ACCEPT description, e.g. beautiful / so people will visit / so people will use it for leisure 2 ACCEPT description, e.g. raise money from visitors 3 ACCEPT description, e.g. keep more species 4 ACCEPT description, e.g. if habitat destroyed there will be a knock-on effect on many species 5 ACCEPT for drugs, pharmaceuticals, GM or GM e.g. (like crop improvement) 6 ACCEPT let native people continue to live in forest income for indigenous people 7 ACCEPT to stop, CO ₂ % rising / global warming / erosion or forest acts as C, sink / store 8 e.g. <ul style="list-style-type: none">• habitat for pollinators• habitat for predators of pests DO NOT CREDIT 'right to life'

Question		Expected Answers	Marks	Additional Guidance
5	(d)	<p><i>management practices</i></p> <p>M1 coppicing / pollarding / description ; M2 selective felling / description ; M3 rotational felling / description ; M4 strip felling ; M5 replant after felling ; (max 2)</p> <p><i>explanation of benefits re. sustainability</i></p> <p>B1 preserves / prevents disruption to, habitat / ecosystems / nesting sites ; B2 maintains / increases, species diversity / biodiversity ; B3 prevents, soil erosion / leaching ; B4 less disturbance by machinery ; B5 AVP ; (max 2)</p>	max 4	<p>LOOK FOR key ideas expressed in different ways</p> <p>M1 CREDIT coppicing with standards / rotational coppicing M2 ACCEPT only some trees cut down M3 ACCEPT cycle of felling different areas</p> <p>B5 CREDIT specific benefits linked to a practice e.g. <ul style="list-style-type: none"> • faster recovery due to seeding from untouched areas nearby (M3) • pollarding so deer can't eat shoots (M1) </p>
		Total	20	

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6	(a)	<p>1 to cope with changing conditions / AW ;</p> <p>2 avoid <u>abiotic</u> stress ;</p> <p>3 to maximise photosynthesis or to obtain more, light / water / minerals ; ora</p> <p>4 avoid, herbivory / grazing ;</p> <p>5 to ensure, germination in suitable conditions / pollination / seed set / seed dispersal ;</p>	max 2	<p>1 Looking for a general statement DO NOT CREDIT “adapt to change”</p> <p>3 CREDIT named elements / ions IGNORE nutrients</p> <p>4 methods of preventing grazing could include producing more toxins / more spines / encouraging stinging ants IGNORE predation</p> <p>5 DO NOT CREDIT ‘maximise reproduction’ without further qualification</p>															
6	(b)	<p>(i)</p> <p>1 in water / in A / with no abscisic acid, germination increases as conc. GA increases ;</p> <p>2 when abscisic acid present / in B, no germination ;</p> <p>3 maximum germination 90% with 5 mol dm⁻³ GA, in water / without abscisic acid ;</p> <p>4 2 comparative figures (x and y refs. plus units) ;</p> <p>5 GA concentration increases, logarithmically / by a factor of 10, on x axis ;</p> <p>6 10 times more GA gives, 3 (conc 0.05 to 0.5) / 0.5 (conc 0.5 to 5), times more germination ;</p>	4 max	<p>2 DO NOT CREDIT ‘inhibits germination’ (as this is a conclusion not a description)</p> <p>3 ACCEPT 91% (± 2%) for 90%</p> <p>4 EITHER compare A and B at the same GA conc OR two points on same line with units for both</p> <table border="1" data-bbox="1346 1209 1921 1433"> <thead> <tr> <th>GA conc (mol dm³)</th> <th>A (%)</th> <th>B (%)</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>10 ± 2</td> <td>0</td> </tr> <tr> <td>0.05</td> <td>22 ± 2</td> <td>0</td> </tr> <tr> <td>0.5</td> <td>66 ± 2</td> <td>0</td> </tr> <tr> <td>5</td> <td>91 ± 2</td> <td>0</td> </tr> </tbody> </table>	GA conc (mol dm ³)	A (%)	B (%)	0	10 ± 2	0	0.05	22 ± 2	0	0.5	66 ± 2	0	5	91 ± 2	0
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6	(b)	(ii)	<p>1 so temperature doesn't affect results / so only desired variable(s) changed / to show just the effect of plant hormones ;</p> <p>2 since temperature affects enzyme activity ;</p> <p>3 suitable / optimum, temperature for (lettuce) germination ;</p>	2 max	<p>1 ACCEPT fair test IGNORE to control temperature / temperature is a limiting factor / temperature is a controlled variable</p> <p>2 CREDIT "optimum temperature for enzyme activity" or "this is the temperature when enzymes work best"</p> <p>3 ACCEPT 'these' seeds</p>
6	(b)	(iii)	<p>1 <u>volumes</u> of liquid(s) ;</p> <p>2 ABA concentration ;</p> <p>3 oxygen availability ;</p> <p>4 age of seeds ;</p> <p>5 previous storage of seeds / viability idea ;</p> <p>6 genotype / variety, of seeds ;</p> <p>7 size / type of, petri dish / filter paper ;</p> <p>8 length of time experiment left for (before recording results) ;</p> <p>9 space between seeds ;</p> <p>10 AVP ;</p>	3 max	<p>Mark the FIRST suggestion on each numbered line DO NOT CREDIT conc, GA / giberrellin (as this is the independent variable) IGNORE number of seeds (as given in the question)</p> <p>1 DO NOT CREDIT amounts / levels CREDIT volume of, water / GA / ABA</p> <p>3 IGNORE carbon dioxide</p> <p>6 CREDIT "from same batch of seeds" or "seeds from same plant"</p> <p>10 e.g. <ul style="list-style-type: none"> ● light qualified (duration / intensity / wavelength) ● use of distilled water ● all lids, off / on </p>

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6	(c)	<p>1 seedless, fruits / grapes ;</p> <p>2 weedkillers ;</p> <p>3 rooting powder / to grow cuttings / used in tissue culture ;</p> <p>4 control fruit ripening ;</p> <p>5 controls fruit drop ;</p> <p>6 restrict hedge growth ;</p> <p>7 preserve, cut flowers / green vegetables ;</p> <p>8 specific example of improved fruit quality ;</p> <p>9 producing malt / in brewing ;</p> <p>10 AVP ;</p> <p>11 AVP ;</p>	2 max	<p>Mark the FIRST TWO suggestions IGNORE the names of plant growth regulators</p> <p>4 could be used to speed up or slow down</p> <p>8 e.g. <ul style="list-style-type: none"> • longer stalks on grapes • longer apples </p> <p>10 & 11 e.g. <ul style="list-style-type: none"> • promoting sexual maturity in conifers • promoting latex flow in rubber plants • promoting sexual maturity in female cucumber plants • longer nodes in sugar cane • restricting growth in, chrysanthemums / other e.g. </p>
Total			13	