Mark scheme - Cloning and Biotechnology

Question			Answer/Indicative content	Marks	Guidance
1			D	1	
			Total	**1**	
2			D	1	
			Total	**1**	
3			D	1	
			Total	**1**	
4			C	1	
			Total	**1**	
5			D	1	
			Total	**1**	
6			C	1	
			Total	**1**	
7			B	1	
			Total	**1**	
8			C	1	
			Total	**1**	
9			A ✓	1 (AO1.1)	**Examiner's Comments** Three quarters of candidates got this right.
			Total	**1**	
10			C ✓	1 (AO1.1)	**Examiner's Comments** Around half of responses were correct. A common misconception was to think that there were no ethical issues associated with the production of mycoprotein.
			Total	**1**	
11			C ✓	1 (AO2.1)	
			Total	**0**	

12	a		suckers / stolons / tubers / rhizomes / bulbs ✓	1(AO1.1)	**ALLOW** other correct methods
	b		meristem(atic) ✓	1(AO1.1)	
			Total	**2**	
13			shoot ✓ explant ✓ sterilise ✓ callus ✓	**4**	**ALLOW** root /stem **ALLOW** disinfect **DO NOT ALLOW** callose **Examiner's Comments** A straightforward question testing AO1, with many correct answers gaining full marks. Most candidates managed root/shoot and sterilise. There was a division between more confident candidates who gained all 4 marks and those who seemed to be guessing the answers. Common errors were giving 'cutting' for explant, confusion between callus (the correct response) and 'callose', and a wide range of answers for 'mass of cells,' such as embryo, blastocyst or zygote.
			Total	**4**	
14		i	reduced / no, genetic variation ⟩ control (more) variables ⟩ increases validity ⟩	**2 max**	**ALLOW** genetically identical / same genetics **ALLOW** same / similar, alleles **IGNORE** same / similar, genes **ALLOW** makes it valid **Examiner's Comments** Most candidates were able to refer to clones being genetically identical. Many were able to communicate that this would remove a confounding variable but few candidates used the technical term: 'validity'. Some attempted to describe validity by using the term 'fair test' or even 'reliable'. Centres are again referred to the OCR Practical Skills Handbook for help with the correct use of such terms.

		ii	*procedure* tissue culture / micropropagation ⟩ *asepsis important because* reduces, microorganisms / contamination ⟩	**2**	**IGNORE** cuttings / vegetative propagation **ALLOW** clear description **ALLOW** without asepsis microbes might grow **ALLOW reduces competition for**, space / nutrients / resources **IGNORE** infection / pathogens **Examiner's Comments** Around half of candidates correctly referred to micropropagation or tissue culture. Cuttings and vegetative propagation were commonly seen un-creditworthy responses. Around half of candidates also correctly suggested that asepsis would reduce microbial contamination. Many were not awarded the second mark because they said simply that infection would be reduced without mentioning microorganisms.
		iii	clone C = 952 ± 2 ⟩⟩⟩	**3**	**ALLOW** 2 marks for any answer between 915 and 990 *If answer is incorrect* **ALLOW** 1 mark for 700 (area of triangle) and **ALLOW 1** mark for 252 (area of rectangle) **Examiner's Comments** Many candidates found the mathematical skills involved in calculating the area of a triangle and rectangle challenging and full marks were awarded for only about a quarter of answers.
		iv	0.76(16) ⟩	**1**	**ALLOW** 76(.2)% / 76/100 / 19/25 / 7.6×10^{-1} **ALLOW** ECF for answer to part (iii) ÷ 1250 **ALLOW** e.g. 0.564 / 56% (if answer to (iii) is 700) **Examiner's Comments** A majority of candidates could divide their answer to part 1 by 1250 and were awarded this mark. However, it should be noted that the question asked for a proportion so answers presented as a ratio were not credited.

		v	(shows) total / cumulative, infection over time (of study) ⟩ *idea that* on different days the level of infection could be different ⟩ any reference Fig.18 to support ⟩	**2 max**	**ALLOW** descriptive or numeric reference **Examiner's Comments** Just under half of candidates scored a mark here – usually for some description of one of the first two marking points. Very few candidates referred to Fig. within their answer, despite being told to do so, so it was rare to award both the available marks. A number of candidates misinterpreted the significance of the word 'visibly', suggesting that the area under the curve could measure invisible infection. Others referred to leaves being shed and gained no credit.
		vi	light <u>intensity</u> ⟩ light duration ⟩ <u>soil</u> (named) mineral (content) ⟩ <u>soil</u>, water / moisture (content) ⟩ soil type ⟩ <u>soil</u> pH ⟩ humidity ⟩ air pollution ⟩	**2 max**	Mark the first 2 answers with exception of ignored answers below. **IGNORE** temperature / wind speed / rainfall **ALLOW** day length **IGNORE** light exposure **IGNORE** nutrients / ions / solutes / nitrogen **IGNORE** water availability **IGNORE** carbon dioxide **Examiner's Comments** Many candidates gained full marks here. Frequent responses that did not gain credit often lacked precision. Examples of this included: 'pH' rather than 'soil pH'; 'soil nutrients' rather than 'soil minerals' or 'amount of light' rather than 'light intensity'. Many candidates suggested atmospheric CO_2 concentration and were not credited as it is unrealistic to suppose that this factor would vary significantly between non-adjacent fields. A small minority of candidates suggested biotic factors.

			Total	**12**	
15			*two from* cutting needs less / micropropagation needs more, (expensive) equipment (1) cutting needs less / micropropagation needs more, (expensive) skills / staff / AW (1) cutting produces less / micropropagation produces more, clone offspring (1) AVP (1)	1	Answers must be **comparative** Look for two separate ideas **IGNORE** refs to time, one or other method may be quicker. e.g. cutting needs less / micropropagation needs more aseptic discipline.
			Total	**2**	
16	a		**1** some crop plants cannot reproduce, sexually / from seed ✓ **2** young seedlings, less likely to survive / AW ✓ **3** quicker than, growing from seed / sexual reproduction ✓ **4** uniform / predictable, shape / size / quality / yield ✓ **5** *idea of* easier to harvest ✓ **6** (propagation) can be done, at any season / time of year ✓	3 max (AO 1.1)	**Mark as prose** **1 ALLOW** seedless / hard to germinate, plants can be grown **4 ALLOW** always get a good yield **4 IGNORE** many copies **Examiner's Comments** Only a few candidates scored marks in this question. Most discussed improvement to crops, which can be achieved by selective breeding or genetic engineering. With the exception of marking point 2, all points on the mark scheme were seen regularly. Most attempts at describing uniformity either did not link it to a desirable quality or merely described increasing the numbers of plants with a given quality. Commonly seen statements such as 'quick', 'cheap' or 'large numbers can be produced' without further qualification were not credited.
	b	i	**1** use a healthy shoot / cut shoot from healthy plant ✓ **2** cut (stem) at a slant ✓ **3** between nodes ✓ **4** (dip in) rooting powder / plant hormone / auxin ✓ **5** place in, soil / compost, and add water ✓	4 max (AO 1.2)	**4 IGNORE** add rooting hormone to, soil / agar **5 ALLOW** place in moist soil

			6 (to reduce transpiration) cover with plastic bag / remove some leaves ✓		**Examiner's Comments** This was anAO1 question about Learning Outcome 6.2.1(a)(ii). A lot of candidates wrote about micropropagation, which is Learning Outcome 6.2.1(b)(i). Those candidates didn't score any marks Others who attempted to describe taking a cutting, were able to gain a mark for dipping the cutting in rooting powder. Most other marking points were seen regularly but very few mentioned choosing a healthy shoot in the first place. **OCR support** OCR 'Delivery Guide' on Cloning and biotechnology (6.2.1): https:/www.ocr.org.uk/qualifications/as-a-level-gce-biology-a-h020-h420-from-2015/delivery-guide/module-ba06-module-6-genetics-evolution-and-ecosystems/delivery-guide-badg023-cloning-and-biotechnology-621
		ii	***Please refer to the marking instructions on this mark scheme for guidance on how to mark this question.*** ***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.) Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer. Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):*	6 (AO 3.3) (AO 3.4)	**Indicative scientific points may include** D increase number of plants in each group E facilitates identification of anomalies E increases accuracy of the mean E allows assessment of repeatability / precision D calculate mean E more representative of treatment D calculate range / standard deviation E add bars to graph E measures variability of results E standard deviation less affected by anomalous results D perform statistical test / (unpaired) Students t-test E assess significance of difference E because comparing 2 means

			• *award the higher mark where the Communication Statement has been met.* • *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.*** **Level 3 (5-6 marks)** Describes in detail how the investigation could be improved **and** fully explains the advantage of these improvements. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated* **Level 2 (3-4 marks)** Describes some improvements to the investigation **and** explains the advantage of at least one of these improvements. *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Describes **or** explains an improvement. *There is an attempt at a logical structure with a line of reasoning. The information is, in the most part, relevant.*		**Examiner's Comments** This level of response question could be answered well using very few of the available answer lines. However, many candidates filled the answer lines with irrelevant material and there was no logical line of reasoning in their answer. Hence, they didn't achieve the communication mark within a given level, particularly at Levels 2 and 3. Most candidates were aware of the importance of replicates but few appreciated that, with an investigation such as this, replication can be achieved by increasing the number of individuals in each group. Few responses communicated this idea clearly, most simply stated 'do it 3 times', which, in the context of an investigation such as this, is not really an appropriate answer. Having mentioned repeats, most candidates mentioned calculating a mean and some were able to say that this would increase the accuracy of the mean. Many responses mentioned identifying anomalies. However, those who stated that anomalies could merely be omitted from a mean without much consideration were not highly credited. Responses that mentioned standard deviation or the use of statistical tests often gained higher level marks. The question stated, in bold, that the investigation had been valid. This was meant to indicate to candidates that discussing improvements to validity would not be credited in this question. However, most candidates either did not appreciate the significance of this statement in the question or did not understand what 'valid' meant. Most responses were filled with discussion of how variables could be controlled. **Misconception** There was a lot of misunderstanding here when using the statistical tests. It is worth noting that using Student's t-test allows us to

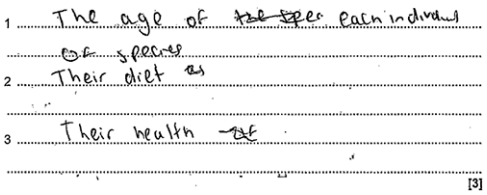
			0 marks *No response or no response worthy of credit.*		assess the significance of a *difference* between two means, not whether the *results* are significant or not. Also standard deviation cannot, on its own, tell us if a difference is significant. **OCR support** Centres can find additional help with maths skills in the OCR Maths Skills Handbook, as well as the Mathematical skills statistics booklet: https:/www.ocr.org.uk/Images/294471-biology-mathematical-skills-handbook.pdf https:/www.ocr.org.uk/Images/338621-mathematical-skills-statistics-booklet.doc Appendix 4 of the Practical Skills Handbook, provides information on terms used in measurement and conventions for recording and processing experimental measurements. This is in line with the 'The Language of measurement' booklet: https:/www.ocr.org.uk/Images/294468-biology-practical-skills-handbook.pdf **Exemplar 7** Repeat the same investigation and collect using cuttings from three different lavender plants and calculate the mean increase in height for fertiliser solutions A and B. * include a control - take a cutting of a lavender plant and place it in soil that hasn't been fertilised at all this will show weather whether the fertiliser solution actually does increase the height of the plants compared to no fertiliser solution at all. * This increases the repeatability of the exp experiment which will increase the confidence in the conclusion. Draw a graph of increase in height [6] Bar against fertiliser solution + add error bars. If error bars don't overlap then the farmer can be more confident in his conclusions, as there is a distinct difference between the heights of plants fertilised by A and B Although there is a small amount discussion about validity in the middle, the majority of the

					answer is correct and relevant and, for the most part, well-expressed so the response achieves Level 2 and the communication mark is awarded. Had the candidate also discussed standard deviation or carrying out a statistical test, it would certainly have achieved Level 3.
			Total	**0**	
17	a		many / AW, explants taken from , original / parent , plant ✓ calluses subdivided ✓ (meristems from) plantlets can be subdivided ✓	2 max(AO1.2)	*All marks are for the idea of multiplication – key terms, such as explant are not essential*
	b	i	**FIRST CHECK ON ANSWER LINE** **if answer is 48(%), award 2 marks.** 16.1/33.8 ✓	2(AO2.7)	*If answer incorrect…* **ALLOW** max 1 mark for correct answer (47.633) to > 2 s.f. **Examiner's Comments** A little over half of candidates got both marks here. The question required the candidates to calculate a percentage change which is a fundamental skill in biology. **OCR support** **OCR's AS and A Level Biology A Biology B (Advancing Biology) Maths skills handbook**
		ii	*Independent variable* BAP concentration ✓ *Dependent variable* shoot length ✓ *Controlled variables* *Any two from…* time light intensity lighting regime temperature (named) nutrient availability (in growth medium)	3(AO3.3)	**IGNORE** mean Mark the first two answers only **ALLOW** composition of , growth medium / agar **Examiner's Comments**

			water availability concentration of other plant hormones pH (of growth medium) ✓		Most candidates could identify the independent and dependent variables, while others got these the wrong way round. Many also offered two correct control variables but several suggestions implied that the investigation might have been done using different plants, rather than clones or that the clones were cultured in soil. Presenting results
			Total	**7**	
18	a	i	nucleus from , tadpole / donor cell , fuses with / enters / AW , (enucleated) egg ✓ using , needle / micropipette / electric pulse / electrofusion ✓	2 (AO 2.5)	**ALLOW** electric , current / shock **IGNORE** injection / electroporation / electricity (unqualified) **Examiner's Comments** Many candidates gave detailed answers that were specific to the process shown in the diagram, enabling them to gain full credit. The most common errors were failing to specify where the nucleus came from or not correctly identifying the practical procedure used. Electroporation was the most common incorrect response.
		ii	*idea that* embryo not implanted into surrogate mother ✓	1 (AO 2.5)	Must imply embryo **Examiner's Comments** Most candidates understood the process and realised that Dolly required a surrogate mother. However, many answers stated that the egg, zygote or nucleus would be implanted, rather than the embryo.
		iii	some genes present in mitochondria from egg cell ✓ random / spontaneous , mutations ✓	1 (AO 2.5)	**ALLOW** mitochondrial DNA **Examiner's Comments** Only a few candidates scored the mark in this question. Some candidates mentioned genetic information from the egg cell but did

					not specify that it would have come from the mitochondria. Some responses mentioned mutations, but usually failed to state that these were random or spontaneous. **Misconception** A common incorrect response was to cite environmental differences showing a misconception about these causing genetic differences in the clone rather than influencing phenotype.
	b	i	(mouse and *Xenopus*) have, different / not comparable, lifespans ✓ (mouse and *Xenopus*) develop / mature, at different rates ✓ frog , has tadpole stage / lays eggs ✓ **ora**	2 max (AO 2.8)	**ALLOW** stage of development at same age is different in each species **ALLOW** takes mouse longer to grow to an adult **Examiner's Comments** Many candidates gained at least one mark here but only few gained two. Many described the non-importance of the 'age of the donor nuclei', implying that it could not be accurately determined or that all nuclei were the same age.
		ii	*idea of any of the following…* **1** (y-axis) does not show health of individual ✓ **2** Dolly was a single individual so perhaps health problems unrelated to cloning ✓ **3** only two species shown so trend might not apply to sheep ✓ **4** only 3 points in, mouse /AW, study ✓ **5** 1962 techniques might not be comparable to Dolly the sheep techniques (in 1996) ✓ **6** correlation does not imply causation ✓	3 max (AO 3.2)	**1 IGNORE** lifespan **3 ALLOW** not done in sheep **5 ALLOW** in context of data generated **Examiner's Comments** Many candidates achieved at least 1 mark. Marking points 1 and 3 were most commonly awarded with some candidates correctly describing other marking points. Critical thinking about the link between evidence and conclusions is an important AO3 skill that will

					be tested in GCE science examinations. Many answers quoted figures from the graph about the success of nuclear transfers in terms of live births which did not answer the question that was asked.
	c	i	goats: 31 / 30.8 mice: 13 / 12.8 ✓✓	2 (AO 2.7)	**Both answers are required for 2 marks.** **ALLOW** 1 mark if one answer is correct and one is incorrect **ALLOW** 1 mark if both answers are correctly calculated but one or both are not given to 2 or 3 s.f. **Examiner's Comments** Most candidates scored 2 marks in this question. The most common errors were incorrect rounding or giving answers with inappropriate numbers of significant figures. **OCR support** The 'Maths for Biology' website offers support on the correct use of significant figures: https:/www.ocr.org.uk/subjects/biology/maths-for-biology/handling-data/
		ii	**1** age / stage of development, of, surrogates / mothers ✓ **2** (general) health of, surrogates / mothers ✓ **3** conditions in which, surrogates / mothers, are kept ✓ **4** age / AW, of (implanted) embryo ✓ **5** age / AW, of nucleus donor ✓ **6** age / AW, of, (enucleated) egg / egg donor ✓ **7** number of eggs implanted in each surrogate ✓ **8** *idea of* accounting for advances in technology (over time) available during procedure ✓	3 max (AO 3.1) (AO 3.3)	**Mark as prose** **3 ALLOW** e.g. diet / healthcare / space **4&5&6 ALLOW** stage of development **5 ALLOW** in context of donor animal or cell **5 ALLOW** type of cell from which nucleus came **8 IGNORE** method of nuclear transfer **8 IGNORE** cloning procedure **Examiner's Comments** Many candidates were able to score at least 1 mark here by identifying one or more factors relating to the surrogate mothers. A

					significant number of answers made vague references to 'animals', without clearly stating which animals they were discussing, surrogate, nucleus donor, egg donor or clone, so they were not credited at this level. Other common errors included references to the number of animals, the breed/species of animal and the method of nuclear transfer. Many candidates appeared to be using the word 'species' to refer to an individual animal.  1 The age of ~~the~~ ~~spec~~ each individual ~~or~~ species 2 Their diet as 3 Their health ~~as~~ [3] **Exemplar 6** The candidate might be thinking along the right lines. However, they have not stated precisely, or at all, which animals are being referred to.
			Total	**0**	
19			*idea that* it ensures the same responses to treatment ✓ *idea that* no genetic variation to affect the results ✓ *idea that* no genetic variation so acts as control variable ✓	1 max (AO2.3)	**IGNORE** 'improves validity' unqualified e.g. produces more valid results as no genetic variation' / 'reduces effect of genetic variation on results' **IGNORE** 'no genetic variation' unqualified **IGNORE** 'acts as a control variable' unqualified **Examiner's Comments** Many candidates scored well on question **(b)** by realising that the hole in the septum wall would allow deoxygenated and oxygenated blood to mix leading to less oxygenated blood being pumped to the cells. Fewer candidates mentioned that some oxygenated blood would be delivered to the lungs or that deoxygenated blood would pass into the left ventricle. In question **(c)** very few candidates linked the information in the question stem with the idea that creatine kinase is an intracellular enzyme found in the blood due to damage to the heart muscle.

					A number of candidates did not gain credit for **(d)** as they did not link clones being genetically identical to the idea that this means genetics has no effect on the results of the experiment and acts as a control variable **Misconception** A common misconception was that the enzyme had brought on the heart attack by causing the heart to produce large amounts of ATP for muscle contraction and overexert itself.
			Total	**1**	
20		i	**1** bacteria gain , nutrient / mineral / food , from , it / detergent ✓ **2** structures / AW (in fig. 21.1) contain <u>only</u> C **and** H ✓ **3** bacteria need (named) elements other than C and H ✓ **4** example of other element linked to use in bacterium ✓ **5** absence of other elements is a <u>limiting factor</u> (for bacterial growth) ✓	3 max (AO3.2)	**3 ALLOW** e.g. bacteria need nitrogen **4 ALLOW** e.g. N for amino acids, P for ATP, O for aerobic respiration Note: bacteria need nitrogen for proteins = 2 marks (mp 3 and 4) **ALLOW** detergent facilitates uptake of hydrocarbons (across plasma membrane) **<u>Examiner's Comments</u>** This high demand, stretch and challenge, question tested AO3 and AO2 skills and most candidates found it very challenging. The question directed candidates to Fig 22 and reminded them about bacterial growth requirements. As the structures in Fig 22 contain only C and H, candidates might have figured out that other elements would be needed to facilitate bacterial growth. However, less than 20% of candidates gained any marks and less than 1% scored all 3. A range of reasonable, but non-creditworthy, answers were seen but many answers

					appeared to be attempting to support Student A's conclusion.
		ii	*idea of* data from investigation that controls surface area or elements available ✓ (information about) elements / AW , present in the detergent ✓	1 max (AO3.4)	**ALLOW** e.g. grow bacteria on small droplets with and without detergent **Examiner's Comments** Less than 1 in 50 candidates scored a mark on this challenging question. A high number of candidates missed it out.
			Total	**4**	
21			Short / AW ✓ pollutants / contaminants ✓ metabolites ✓	3 (AO1.1)	**ALLOW** pollution / contamination / waste / oil / solvents /pesticides / benzene / plastics / chemicals **IGNORE** impurities / faeces / toxins / bacteria / pathogens
			Total	**3**	
22		i	***Please refer to the marking instructions on of this mark scheme for guidance on how to mark this question.*** ***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* • *award the higher mark where the Communication*	6 (AO1.1)	**Indicative scientific points may include:** *Advantage*: low cost *Explanation*: many microorganisms require only low temperatures / few energy requirements / nutrients for growth are cheap (e.g. waste materials) *Advantage*: large numbers can be produced quickly / high yield of product *Explanation*: short generation time / reproduce quickly *Advantage*: better for the environment / less pollution *Explanation*: reduces use of land for food production / lower energy requirements *Advantage*: can be produced in many locations *Explanation*: not affected by climate / easy to control conditions *Advantage* : suitable food for vegans / more healthy food

			Statement has been met. • *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The communication statement determines the mark within a level.*** **Level 3 (5-6 marks)** Describes and explains advantages, using examples. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated* **Level 2 (3-4 marks)** Describes advantages, with some examples, but little explanation. *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Describes some advantages, but with little or no explanation and few or no relevant examples. *There is an attempt at a logical structure with a line of reasoning. The information is, in the most part, relevant.* **0 marks**		*Explanation*: low in cholesterol and high in protein or fibre / easy to genetically engineer to improve food quality Examples (list not exhaustive) • (Brewer's) yeast / for alcohol • (Baker's) yeast / for bread • *Lactobacillus* / for cheese / yoghurt • *Fusarium* / for mycoproteins • Pectinase / from *A. niger* / fungus / for fruit juice • *Aspergillus* / yeast / for soya sauce • fungal lactase / for lactose free milk **Examiner's Comments** As with Q4(b), a good range of marks were seen for this level of response question. A fair proportion of candidates did not mention examples of foods or microorganisms used in food production; they were consequently restricted to Level 1. Quorn was by far the most commonly referenced example. Candidates tended to describe and explain advantages quite confidently. **AfL** Candidates should be aware of some common examples of microorganisms used in food production. **OCR support** OCR delivery guide on 'Cloning and biotechnology': https:/www.ocr.org.uk/qualifications/as-a-level-gce-biology-a-h020-h420-from-2015/delivery-guide/module-ba06-module-6-genetics-evolution-and-ecosystems/delivery-guide-badg023-cloning-and-biotechnology-621 **Exemplar 3**

			No response or no response worthy of credit.		Microorganisms have a very fast growth rate - exponential growth - therefore their production is very efficient to produce large quantities of food. Microorganisms require low temperatures for optimum growth, therefore have a low energy demand production and do not use much electricity, and less fossil fuels are required to be combusted. Furthermore, they require very little nutrients for optimum growth therefore are relatively easy to synthesise. They can be easily genetically engineered using DNA transfer and vectors to produce desired [redacted] food using specific [6] genes. They can be produced using continuous, or batch fermentation, and only require a supply of oxygen, nutrients, an optimum pH, and a stirring mechanism. There is a very large number of microorganisms available, and they all produce different useful metabolites. Exemplar 3 has plenty of advantages and explanations, but unfortunately it lacks any named responses of foods or microorganisms. This limits the mark to 2/6 (L1). **Exemplar 4** Microorganisms reproduce very quickly and produce lots of useful products quickly: they are easy to maintain and dont require complicated conditions. They can be grown in fermentation vessels with specific conditions for temperature, pH, nutrients and sterile air. Microorganisms, like yeast can be used to produce beer and bread. They respire anaerobically to produce ethanol for beer and produce a rising affect in bread. Microorganisms can also be used to produce lactose-free dairy products for lactose-intolerant people. Eg they are used to for milk, cheese and yoghurt. They are also needed in these products to cause them to become the right consistency. Microorganisms like bacteria can be used to make GM [6] crops to create a large yield and contain beneficial genes. Microorganisms are cheap to use and can be grown easily, hence it being beneficial to use them. Exemplar 4 has several advantages and explanations, and has listed several responses of microorganisms and foods produced by them. This allows this answer to access Level 3 - 6 marks
		ii		3 (AO1.2)	

			<table><tr><th>Statement</th><th>Batch</th><th>Continuous</th></tr><tr><td>Waste is removed during the fermentation process</td><td></td><td>✓</td></tr><tr><td>A fixed volume of nutrient medium is used</td><td>✓</td><td></td></tr><tr><td>Secondary metabolites are more likely to be produced</td><td>✓</td><td></td></tr><tr><td>The growth rate tends to be faster</td><td></td><td>✓</td></tr><tr><td>The culture is grown for a fixed period of time</td><td>✓</td><td></td></tr></table> ✓✓✓		All 5 correct = ✓✓✓ 4 correct = ✓✓ 3 correct = ✓ **Examiner's Comments** On the whole, this question was well answered, with most candidates gaining 2 or 3 marks. The most common errors were for statements 3 and 4 in the table, with many candidates believing secondary metabolites are produced in continuous fermentation, and that growth rate is faster in batch fermentation.
			Total	**9**	
23			*Any four from:* microorganisms grow more quickly and can produce more protein per, hour / day / week (1) microorganisms can be grown on waste material from other processes (1) beef has five times the total fat content of protein produced by microorganisms ORA (1) beef has 20 times the saturated fat content and is more likely to contribute to	4	**ACCEPT** reverse argument **ACCEPT** reverse argument **IGNORE** 'more' or 'less'

			atherosclerosis / heart disease ORA (1) fungal protein has no cholesterol and is less likely to contribute to, atherosclerosis / heart disease (1) people on a weight reduction diet prefer fungal protein as it has half the energy content of beef (1) AVP (1)		**ACCEPT** reverse argument **IGNORE** 'more' or 'less' e.g. rearing beef takes up a lot more land
			Total	**4**	
24			*two from* work in an inoculating cabinet / maintain minimum plate-opening time (1) flame inoculating loop / use sterile, pipette tip / implement of transfer (1) seal the plates for incubation (1)	2	**IGNORE** refs to safety – question is about sterile practice. **IGNORE** autoclave, irradiation etc., as done before technician gets sample.
			Total	**2**	
25	a		*flaming the tube* causes air to expand and pushes bacteria away so less likely to settle into tube (1) kills bacteria on neck of tube (1) *holding lid of petri dish over agar plate* avoids infection / inoculation with bacteria in the air (1)	2	
	b		dilute the sample taken from the colony (1) multiply result from agar plate by dilution factor (1)	2	**ALLOW** for serial dilution, choose the correct plate (highest number of colonies without colonies merging)
	c	i	65 (1)(1)	2	Correct response = two marks. If incorrect response allow one mark for working: $\frac{(20-7)}{20} \times 100$

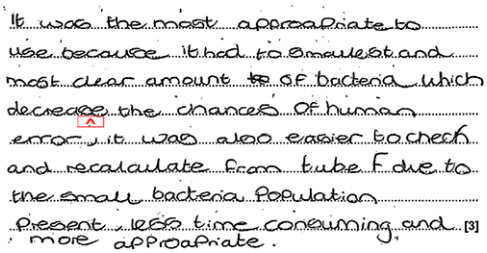
		ii	*Species B* [no mark] produces more biomass (1) continues to produce biomass at low glucose concentration (1)	2	
			Total	**8**	
26		i	1. (at start) respiration is <u>anaerobic</u> / glucose converted into ethanol✓ 2. respiration, decreases rapidly / stops , once glucose used up ✓ 3. ethanol used (as a carbon source) once glucose has been consumed ✓ 4. aerobic respiration (of ethanol) ✓ 5. (because) acetyl Co A used in Krebs cycle ✓ 6. respiration stops when, ethanol / respiratory substrate, has been used up ✓	**3 max**	**ACCEPT** oxygen is needed for the metabolism of ethanol **Examiner's Comments** This question proved to be a good discriminator. This was a difficult graph to interpret and some candidates were confused in their answers. There were numerous responses based entirely on recall of aerobic respiration followed by anaerobic respiration when yeast is used to produce ethanol. Candidates seemed quite happy to ignore or misrepresent the evidence of the graph to fit with their preconceptions. Good candidates just looked at the evidence and drew the correct if unfamiliar conclusion, which was that anaerobic respiration was followed by aerobic respiration. Weaker candidates did not get to grips with the idea that glucose was used as a respiratory substrate at first, and then ethanol. Neither did they link that with the type of respiration. Weaker candidates often gave a detailed description of the graph, quoting data in great detail, but did not mention the type of respiration occurring rather taking the approach of manipulating data, which gained no credit.

		ii	(use) aseptic techniques / avoid contamination ✓ provide (sources of) nutrients / respiratory substrates ✓ (incubate at) suitable temperature ✓ use (pH) buffer ✓ agitation / stirring / shaking ✓	**2 max**	**Mark first two suggestions given** **ACCEPT** a description of an aseptic technique **ACCEPT** sterile techniques **ACCEPT** a specific example of a nutrient **ACCEPT** optimum temperature / right temperature /a specific, appropriate temperature (15 – 35°C) **IGNORE** keep temperature constant / low temperature/ monitor temperature / control temperature **ACCEPT** maintain optimum pH / right pH /a specific, appropriate pH (4–7) **IGNORE** keep pH constant / monitor pH / control pH **ACCEPT** mixing **IGNORE** ref to aeration / oxygen supply / sparging **Examiner's Comments** This was well answered on the whole, and many candidates scored two marks. The majority of candidates got two marks for mentioning the use of aseptic techniques and mark point 3 or 4 for the use of optimum temperature or optimum pH. Some candidates stated control temperature and pH rather than the idea that these factors needed to be suitable for the yeast, and it was disappointing to see that some candidates suggested that the 'culture' should be sterilised, which gained no credit.
		iii	3.75 ✓ x 10^5 ✓	**2**	**One mark** awarded for a correct calculation with the wrong number of significant figures or not in standard form (e.g. 375000 , 375 x 10^3 ,3.8 x10^5) **Examiner's Comments** Many candidates had trouble with this calculation. It was clear which candidates had been taught how to calculate population numbers in relation to dilutions. However, a large proportion of the candidates then failed to give their answer in standard form or to

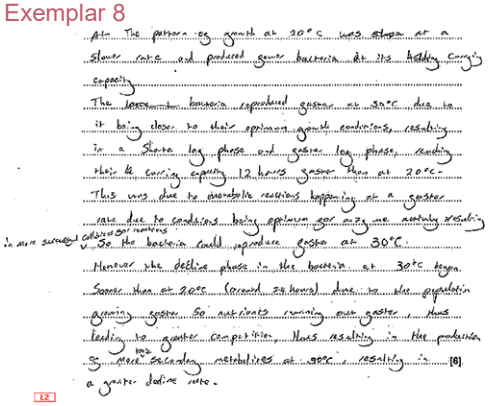
					three significant figures, and so only gained one mark. It is important that centres make sure that candidates know how to calculate serial dilutions and are able to put their answer into standard form and the correct number of significant figures. Some candidates were able to work out that there were 150 bacteria in 1 ml of 10^{-2} dilution, but then got confused and were unable to convert this to 15000 in 1 ml of original culture and hence then calculate 15000 x 25 = 375000 (3.75×10^5) in 25 cm^3 of the original culture.
		iv	*Yes because…* a suitable, range / intervals, of temperatures have been chosen ✓ volume controlled ✓ temperature , controlled / maintained ✓ repeats, to identify anomalies / outliers ✓ same yeast suspension used ✓ *No because…* availability of, oxygen/ nutrients / yeast concentration, not controlled ✓ pH is not be controlled at start of experiment ✓ *idea of* pH change would not be an accurate measure of respiration rate ✓ no time reference (to calculate rate) ✓ no control (sample) ✓	**3 max**	**Max 2 for statements supporting only one view** **IGNORE** large / wide, range of temperatures **IGNORE** repeats exclude anomalies **ACCEPT** ‘better to collect (volume of) carbon dioxide produced’ / ‘It is better to use a respirometer’ (implies pH change not accurate) ‘because some CO_2 would diffuse into the air’ **Examiner’s Comments** Many candidates scored well on this question and it was good to see how many realised that using a pH probe is not an accurate way to measure respiration rate. However, some candidates used very vague language, such as ‘a range of temperatures’ without qualification, and a sizeable proportion gave only ‘yes, because…’ or ‘no, because…’ answers, obviously not understanding the significance of term ‘evaluate’. Candidates need to be taught that when asked to evaluate they need to put arguments for and against. Weaker candidates suggested that

					pH needed controlling which showed a lack of understanding of the question. A number also did not get mp 4 under the Yes section because they did not mention that by doing repeats one can help to identify the anomaly. Instead they went one step further and were mentioning removing the anomaly or discarding it in order to calculate the mean.
		v	difference (between the means), is not significant / can be explained by chance (at p = 0.05) ✓	**1**	**ACCEPT** null hypothesis / H_o, can be accepted **DO NOT ACCEPT** null hypothesis / H_o can be rejected **ACCEPT** the results are not significantly different (p = 0.05) **Examiner's Comments** This was well answered, showing that many candidates seem to understand how to interpret statistical calculated values. It was clear that many candidates had been taught this basic statistical test and what it showed. However a significant number of students still gave confusing answers and failed to understand that if the *t* value is less than the critical value at p = 0.05, the null hypothesis should be accepted and there is no significant difference. They often confused results not being significantly different with the null hypothesis being rejected so they ended up getting no marks. Very weak candidates just stated that the results were not different. The words significant or different were missing from the responses.
			Total	**11**	
27	a		**1** volume of broth (in flask) ✓ **2** pH (of broth) ✓ **3** oxygen (concentration in flask) ✓ **4** number / concentration , of bacteria in , broth at beginning / AW ✓ **5** **6**	1 max (AO3.4)	**IGNORE** 'amount' throughout **4 ALLOW** batch of broth / starting population of bacteria **4 IGNORE** volume / mass **Examiner's Comments** Most candidates were aware that conditions ought to be as similar as possible and around

			volume removed (from each flask) ✓ (standard) stirring / mixing , before withdrawal of samples ✓		half achieved a mark by stating one of marking points 2 to 5. As usual in these questions, the vague word 'amount' did not achieve any credit. Irrelevant responses such as 'size of flask' and 'light' were seen but received no credit. Some candidates described a control sample and gained no credit.
	b	i	6.0 / 6 , × 10^7 ✓✓	2 (AO2.8)	*Max 1 if answer not given as standard form* **ALLOW** 1 mark for 6 × 10^6 / 6 × 10^8 **Examiner's Comments** Less than 20% of responses achieved both marks. Candidates fell into one of two similarly-sized groups: those who clearly knew how to calculate number of bacteria and were either correct or out by a factor of 10 or 100, and those who did not know how to approach the calculation at all. Some candidates ignored the instruction to write the answer in standard form and so were limited to 1 mark.
		ii	**1** should have used E ✓ **2** (has) most / more , (countable) colonies ✓ **3** *idea that* anomalies will have smaller effect ✓ **4** more representative / larger , sample ✓ **5** (fewer serial dilutions) decreases chance of error ✓ **6** F (is appropriate) because , colonies / AW , are countable ✓	3 max (AO3.1) (AO3.4)	**1** Other points can be awarded in the context of plates other than E **2-5 ora** for F **4 ALLOW** estimate will be more accurate **4 IGNORE** valid / reliable / repeatable **6 ALLOW** bacteria as AW for colonies for this marking point only **Examiner's Comments** Most candidates gained at least 1 mark but it was rare for a response to achieve all 3. Many candidates thought that F was the most appropriate and this limited their score to 1 mark. Candidates who discussed reasons why F might not have been the best tube often achieved a mark for discussing diluting error or marking point 3 in some form.

					However, many such candidates seemed reluctant to clearly state that E would have been the best tube to use. Marking point 2 was rarely credited because few candidates used the word 'colonies'. A significant minority of candidates seemed to think that E would be inappropriate because someone might make a mistake when counting; such responses were not credited. Candidates are advised that answers to practical questions that cite avoidable human error are not likely to attract marks. Exemplar 7  It was the most appropriate to use because it had to smallest and most clear amount of bacteria which decreage the chances of human error, it was also easier to check and recalculate from tube F due to the small bacteria population present, less time consuming and more approapriate. [3] This is an example of a response that suggests that human counting error is the main concern when selecting which tube to use and hence achieves no marks. Typically, this type of response often achieved marking point 6 but this one does not explicitly state that the colonies in tube F are countable, hence the omission mark, so no marks were credited.
	c	i	**Level 3 (5–6 marks)** Describes the main differences between the two temperatures using key terms **and** explains in detail the difference between temperatures. *There is a well-developed line of reasoning which is clear and logically structured and uses scientific terminology at an appropriate level. All the information presented is relevant.* **Level 2 (3–4 marks)** Describes some differences between the two temperatures	6 (AO2.7) (AO2.8)	**Indicative points may include** *Comparison of curves* • similar lag phase • quicker overall at 30°C • exponential phase rises faster at 30°C • shorter duration of stationary phase at 30°C • faster death phase at 30°C • lower population at 30°C after 72h • figures used to support *Explanation for difference at higher temperature*

			with some use of key terms **and** explains a difference between temperatures. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented is mostly relevant.* **Level 1 (1–2 marks)** Describes some differences between the two temperatures or explains a difference between temperatures. *The information is communicated with only a little structure.* *Communication is hampered by the inappropriate use of technical terms.* *0 marks* *No response or no response worthy of credit.*		• molecules have more kinetic energy • bacterial enzymes closer to optimum temperature • faster enzyme activity • more competition for nutrients earlier • resources, e.g. carbon source, used up more rapidly • mineral availability becomes limiting factor more quickly • toxic metabolites produced more quickly **Examiner's Comments** Some candidates achieved Level 3 for this question but Level 1 was the most commonly credited. In order to achieve Level 3 a response needed to make clear comparative statements about both curves and to explain the reasons for differences between the two temperatures using key A Level terminology. Most candidates compared the curves but responses that were credited lower level marks often displayed a sequential, narrative style which could not really be considered a comparison. Equally, many candidates did not even attempt to *explain* differences as so were limited to Level 1. Descriptions of phases provided an opportunity for candidates to display their ability to use technical terms but a sizeable minority of candidates did not take this opportunity, often referring to a 'growth in numbers', without reference to the term 'lag phase', for example. While some, usually Level 3 responses, did offer relevant explanations at an appropriate standard, many responses merely explained the phases of a bacterial growth curve, without reference to the data provided in the question. Some attempts at explanation did not raise the level of an answer because of basic errors when discussing enzymes. Enzyme action is frequently assessed in biology examinations. With reference to

					common errors, candidates are reminded of the following: the term 'optimum temperature' applies to enzymes, not bacteria; it is reasonable to describe enzymes or molecules as having 'more kinetic energy' but not bacteria; and the death phase of a growth curve does not cause, nor is a result of, denaturation of bacterial enzymes. Exemplar 8  The main differences between the two temperatures are described using key terms and there are multiple explanations for the differences between the temperatures. The response is coherent, relevant and uses A Level scientific terminology.
		ii	<u>control</u> ✓ *idea of* checking for contamination ✓	2 (AO3.3) (AO3.4)	**DO NOT CREDIT** control , group / variable / condition **ALLOW** shows growth due only to **B. subtilis** **ALLOW** e.g. to ensure conditions were aseptic / if the flask had bacterial growth the results would be invalid **<u>Examiner's Comments</u>** Most could establish it was a control, although some confused this control with a control variable or control group. Many were able to link this to the idea of checking for unintended bacterial growth. The context should have clearly signalled the idea of contamination so, on this occasion, responses that gave generic answers about comparisons were not credited.
		iii	*idea that* it could encourage the growth of human pathogens ✓	1 (AO3.3)	**ALLOW** harmful microbes could grow **DO NOT CREDIT** refs to denaturation **IGNORE** bacteria will grow rapidly which

					could be dangerous **Examiner's Comments** About a third of candidates achieved this mark. Incorrect responses often referred to enzymes denaturing (which is unlikely at 35°C) or rapid uncontrollable growth.
		iv	reduce impact of , anomalous / AW , results ✓ measure / increase / show / ensure , repeatability ✓ allow , calculation of standard deviation / (named) statistical test ✓ (calculated) mean likely to be , more accurate / closer to true value (than individual value) ✓	3 max (AO3.3)	**IGNORE** identify / ignore / exclude **ALLOW** reliability **IGNORE** valid / accurate **ALLOW** any named statistical test **Examiner's Comments** Correct use of the term 'repeatable' and appropriate use of 'accurate' were able to gain credit as part of a correct explanation; in the context of this question, 'valid' was not relevant. Help with the correct use of the language of measurement is available in the OCR Practical Skills Handbook. Most responses achieved one mark, usually for reference to the idea of repeatability. All marking points were credited, but marking point 2 was by far the most frequently credited. It is worth reminding centres that discarding results purely on the basis of their being different from the mean is a very questionable practice. Anomalous results should only be excluded if there is a clear explanation for why they occurred. If not, while they might trigger further replicates or affect the outcome of a statistical test, they ought to be included in any calculated means. Replicates will, however, minimise the impact of any outlying data on those means.
			Total	**18**	
28			***Please refer to the marking instruction point 10 for guidance on how to mark this question.*** ***In summary:*** *Read through the whole answer. (Be prepared to*		

			recognise and credit unexpected approaches where they show relevance.) Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, ***Level 1, Level 2*** *or* ***Level 3****, best describes the overall quality of the answer. Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* • *award the higher mark where the Communication Statement has been met.* • *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.***		
			Level 3 (5–6 marks) A good range of correct modifications are provided. Each modification is explained. Comments both on improvement to the investigation **and** on validity are included. *The explanations are clearly linked to the modifications with a well-reasoned explanation of how the modification will work.* **Level 2 (3–4 marks)**	6	**Indicative scientific points may include:** **Modifications:** 1. Take samples more frequently than every four hours 2. Use a spreader to spread the bacteria on the agar 3. Label petri dish as soon as inoculated 4. Place petri dishes upside down 5. Use a wider range of temperatures / use more intermediate temperatures

			Some correct modifications are provided. Each modification is explained. Comments on improvement to the investigation and / or on validity are included. *The explanations are clearly linked to the improvements but it may not be clear how the modifications will work to improve the investigation or make the results more valid.* **Level 1 (1–2 marks)** Limited correct modifications are provided. There are no clear explanations of how the modifications will improve the investigation or validity of the results. OR Only one correct modification is described with a clear explanation of how it will improve the investigation or validity. *There is a logical structure to the answer. The explanation, though basic and not linked to the modification, is clear.* **0 marks** No response or no response worthy of credit.		**Explanations:** 1. Bacteria can reproduce (very) quickly and a big change could occur in four hours so detail of growth may be missed 2. Tilting / swirling the plate may not spread the bacteria evenly and this would make counting the colonies more difficult and cause the result to be invalid 3. The dishes could easily be confused or mixed up so that the results are invalid 4. Prevents the agar drying out which would reduce bacterial growth and make the results invalid 5. Provides more information about the effect of temperature
			Total	**6**	
29		i	*'For' statement:* no lag phase (is shown) ✓ no (clear), stationary / death / decline, phase ✓ *idea that* decrease between day 3 and 4 is not typical of standard growth curve ✓	4 max (AO3.1)	**ALLOW** clear descriptions of stages of growth curve e.g 'there is no fall in number of cells at end of growth curve'

			'Against' statement: *idea that* lag phase may be present but day 0 data are not shown ✓ exponential / log / rapid growth, phase present (between day 1 and 2) ✓ *idea that* stationary / death / decline, phase may occur later ✓ *General point*: *idea that* presence of limited nitrate is responsible for the (non-standard) growth curve ✓		e.g. 'lag phase may occur between day 0 and day1' **ALLOW '**growth rate increases (between days1-5) but then rate of growth slows down' e.g. 'reduction in nitrate could lead to fall in cell numbers between day 3 and 4' / 'as nitrate levels fall bacterial cell numbers are still increasing'
		ii	**FIRST CHECK ON ANSWER LINE** **If answer = 2.5 × 10^6 award 3 marks** $10^{4.7}$ = 50,118.72336 ✓ × 50 (= 2,505,936.168) ✓ standard form = 2.5 × 10^6 ✓	3 (AO2.4)	**ALLOW any value between $10^{4.5}$ and $10^{4.8}$** **i.e. 1.6 - 3.2 × 10^6 award 3 marks** **ALLOW** 31,622.7766 – 63,095.73445 **ALLOW** any correct rounded value This mark should be awarded to 'x50' seen anywhere in the working, regardless of the value being multiplied This mark should be awarded for correctly converting to standard form, regardless of the value being converted as **ECF** **MAX 2** for correct answer not converted to standard form
		iii	serial dilution ✓ *idea of* grow colonies (on agar plate) and count number of colonies ✓ *idea of* scale up / multiply up, count (to estimate population size) ✓	2 max (AO2.7)	**ALLOW** *idea of* flow cytometry / described
			Total	**9**	
30			*two from* (enzymes) re-used so less, **money** / **cost** (for new ones)	2	**Mark the first answer on each prompt line.** If the prompt numbers are ignored, mark the **first two answers** as prose. Answers **must**

			(1) downstream processing / purifying, **cost / expense**, reduced (1) (higher temperature allows) more **profit** from faster yield (1)		refer to reduced cost / losses / expense, or increased profit. **ALLOW** ORA for any point if clearly stated **IGNORE** 'more economic' in general e.g. 'Continuous processing is more economic'. Look for the details listed.
			Total	**2**	
31	a		in, (named) matrix / gel ✓ adsorption / bonding to (named) carrier ✓ membrane separation ✓ cross-linking / covalent bonding ✓	1 max AO1.2	**ALLOW** entrapment / encapsulation / inclusion / microcapsulation **ALLOW** carrier bound **ALLOW** attached to partially permeable membrane
	b	i	**FIRST CHECK ON ANSWER LINE** **If answer = 6.8 +/- 0.8 award 2 marks** 7.5/1.1 = 6.8181· ✓ rounded to 2 s.f. = 6.8 ✓	2 AO2.4	**ALLOW** mp 2 for incorrect answer rounded to 2 s.f
		ii	smooth curve **AND** goes through or near at least 7 points ✓	1 AO3.3	**DO NOT CREDIT** extrapolations
		iii	**1** no value between pH5.5 and pH6 measured ✓ **2** peak / optimum , could be anywhere between pH5.5 and pH6 ✓ **3** peak / optimum , for immobilised tannase could be anywhere between pH 5 and pH6.5 ✓ **5** no indication that the experiment has been repeated ✓ **6** AVP ✓	3 max AO3.2	**1 ALLOW** without smaller intervals the student cannot be certain **1 ALLOW** examples of untested pH values within this range **2 & 3 DO NOT CREDIT** optimum *is 5.75* **5 ALLOW** enzyme activity is not stated as a 'mean' **5 IGNORE** not repeated **6 CREDIT** pH scale is , non linear / logarithmic **6 CREDIT** 10 a.u. is V_{max} for this enzyme
		iv		2 max AO2.2	**ALLOW ora** for free tannase throughout **ALLOW** does not denature

			(immobilised enzymes are) less easily denatured ✓ shape / tertiary structure , supported / AW (by support material) ✓ *idea that* part of enzyme not fully exposed to pH (8) ✓		**ALLOW** bonds less easily disrupted
	c	i	**1** product not contaminated with enzyme ✓ **2** extraction of , product / enzyme , not needed ✓ **3** recycling (of enzyme) ✓ **4** *idea that* process can be run over wider temperature range ✓ **5** (bioreactors) can be run continuously for long periods, so less emptying / cleaning needed ✓	2 max AO1.2	**2 ALLOW** reduced downstream processing **3 ALLOW** enzyme can be reused / less enzyme needed **4 ALLOW** e.g. can be run at lower temperatures so less energy cost / can be run at higher temperatures so faster
		ii	high(er) , initial / set-up , costs ✓ fewer exposed active sites ✓ *idea that* immobilization method might affect shape of active site ✓ *idea of* leakage ✓	1 max AO1.2	**ALLOW** immobilization process is expensive **IGNORE** more expensive to buy **ALLOW** active sites and substrates mix more slowly
			Total	**12**	