HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.8.4 Gene technologies (part 2)

Mark scheme

Version 1 · 22 October 2026

TOTAL MARKS	QUESTIONS
68	8

How to use this mark scheme

;	Separates marking points. Each semicolon marks the end of one creditable point, and each point is worth one mark.
;;	Two marks for this answer (used for calculations).
/	Alternative words or phrases that are credited for the same point.
OR	An alternative answer for the same mark.
( )	Words in brackets are not needed to gain the mark.
max	More marking points are listed than marks available. Award up to the number of marks shown.
Accept	An alternative answer that gains credit.
Reject	A wrong answer. It does not gain credit and cancels a correct point it contradicts.
Ignore	Neither credited nor penalised. Mark the rest of the answer.
ECF	Error carried forward: credit correct working that uses an earlier wrong answer.
AO	Assessment objective: AO1 knowledge and understanding; AO2 applying knowledge; AO3 analysing, interpreting and evaluating.

Where an answer is correct but not listed, credit it if it is biologically accurate and answers the question at the depth the marks require. Right + wrong = wrong: a contradiction cancels a correct point.

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Making genes and amplifying them in host cells 3.8.4.1

Question	Marking guidance	Mark	Comments
01.1	1. Find/decide the amino acid sequence of the modified phytase (the fungal sequence with the six changes); 2. Use the genetic code to work out the codons/mRNA base sequence and so the DNA base sequence that codes for it; 3. Enter the DNA base sequence into a computer (that controls the gene machine); 4. Nucleotides are joined one at a time in the required order to make short (single-stranded) sections of DNA/oligonucleotides; 5. The (overlapping) short sections are joined to make the complete gene; 6. The gene is made double-stranded/copied (eg by PCR) before it is inserted into a plasmid;	**4 max** (4 × AO1)	2. **Accept** 'triplets' for codons 4. **Accept** 'the machine adds nucleotides in the order of the base sequence' **Reject** use of a template/mRNA/reverse transcriptase by the gene machine for point 4 **Ignore** 'the computer makes the gene' unqualified

Question	Marking guidance	Mark	Comments
01.2	Reverse transcriptase;	**1** (1 × AO2)	A gene machine makes the gene without an mRNA template, so reverse transcriptase is not needed. A restriction endonuclease is still needed to cut the plasmid, and DNA ligase to join the gene into the plasmid.

Question	Marking guidance	Mark	Comments
01.3	1. The modified base sequence does not exist in the fungus (so there is nothing to cut out or copy), but a gene machine can make any designed sequence, including the codons for the six different amino acids; 2. Sticky ends/recognition sites (for a restriction endonuclease) OR a promoter/terminator can be built into the gene as it is made; 3. Codons can be chosen that the bacterium translates efficiently OR the gene can be made without introns, so the bacteria can express it;	**2 max** (2 × AO2)	1. **Accept** 'no template is needed for a sequence that does not exist'; 'no template is needed' alone is not enough 3. **Accept** 'bacteria cannot remove introns' for the second alternative **Ignore** 'quicker/cheaper/easier' unqualified **Reject** 'the gene machine changes the fungal gene'

Question	Marking guidance	Mark	Comments
02.1	1. Plate 1 shows that the bacteria were alive/able to grow on this agar (after the treatment); 2. Plate 2 shows that bacteria without the plasmid/gene R are killed by/cannot grow with antibiotic K; 3. So colonies on plates 3 and 4 must have come from bacteria that took up the plasmid/were transformed;	**2 max** (2 × AO3)	**Accept** 'as controls' only if the purpose is explained 2. **Accept** 'antibiotic K works/is effective' 3. **Accept** 'so the antibiotic selects only transformed bacteria' **Ignore** 'to make it a fair test' unqualified

Question	Marking guidance	Mark	Comments
02.2	1. Bacteria on both plates contain the plasmid/gene G, because they grew with antibiotic K; 2. On plate 4, sugar A allows transcription of gene G (at its promoter), so the fluorescent protein is made/translated; 3. On plate 3, there is no sugar A, so gene G is not transcribed/expressed (and no fluorescent protein is made);	**2 max** (2 × AO2)	**Ignore** 'switched on/off'; points 2 and 3 need transcription or expression 2. **Accept** 'RNA polymerase can bind to the promoter when sugar A is present' **Reject** 'bacteria on plate 3 do not have gene G'

Question	Marking guidance	Mark	Comments
02.3	Correct answer for 3 marks: 8.1×10^3;;; Accept for 2 marks: 8100 (correct value not in standard form) Accept for 1 mark: 0.01 µg (of plasmid DNA) on plate 4 OR 0.10 ÷ 0.50 = 0.2/one fifth of the mixture spread OR 81 × 5 = 405 colonies (in the whole mixture)	**3** (3 × AO2)	0.050 × 0.10 ÷ 0.50 = 0.01 µg; 81 ÷ 0.01 = 8100 Also correct: 81 × 5 = 405 colonies from the whole mixture; 405 ÷ 0.050 = 8100 1.62×10^3 (81 ÷ 0.050, volume not taken into account) gains 0 marks

Question	Marking guidance	Mark	Comments
02.4	1. Use a sterile pipette/syringe (to transfer the bacteria); 2. Use a sterile spreader, eg dipped in alcohol and flamed; 3. Lift the lid of the plate only slightly/at an angle; 4. Work close to (the upward air movement from) a Bunsen burner flame; 5. Disinfect the bench/surfaces OR wash hands with soap; 6. Place used pipettes/spreaders into disinfectant (immediately after use); 7. Flame the neck of the bottle/tube of bacteria after removing the lid; 8. Contaminating microorganisms that are resistant to antibiotic K could grow on plate 4 and be counted as transformed colonies;	**3 max** (2 × AO1) (1 × AO2)	**Max 2** from points 1 to 7; point 8 is required for 3 marks 1. **Reject** loop for the pipette; accept an unopened/sterile pipette or syringe 2. **Accept** a loop for the spreader; accept 'dip in disinfectant and rinse (in sterile water)' as a way to sterilise the spreader 3. **Accept** 'keep the lid over the plate' 4. **Accept** 'convection current' for upward air movement; reject 'air movements sterilise the air' 5. **Ignore** 'sterilise hands/surfaces'; accept 'sanitise' or a named disinfectant 8. **Accept** 'contaminants form extra colonies, so more colonies are counted' 8. **Accept** answers that note contaminant colonies would not fluoresce, so they would add to the count only if every colony were counted (not only fluorescent ones) OR that contaminated pipettes/spreaders could carry extra transformed bacteria onto the plate **Ignore** 'work quickly with the lid off'

Question	Marking guidance	Mark	Comments
02.5	1. The bacteria divide (rapidly) by binary fission; 2. The plasmid (containing the gene) is replicated (before the bacterium divides) OR each bacterium may contain several copies of the plasmid; 3. Each daughter cell receives (a copy of) the plasmid/gene; 4. All the bacteria are descended from one transformed bacterium, so all contain the gene; 5. The number of bacteria/copies of the gene increases exponentially/doubles each generation;	**3 max** (3 × AO1)	3. **Accept** 'antibiotic K kills any bacteria that lose the plasmid' for point 3 **Reject** mitosis for binary fission **Ignore** references to PCR

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Evaluating recombinant DNA technology 3.8.4.1

Question	Marking guidance	Mark	Comments
03.1	1. The antibiotic-resistance gene could be transferred to bacteria (eg in soil or in the gut of animals), so pathogens could become resistant/the antibiotic would no longer treat infections; 2. A fluorescence marker gene gives no antibiotic resistance/no selective advantage to bacteria OR GM cells can be detected by looking for fluorescence, without using antibiotics;	**2** (1 × AO1) (1 × AO2)	1. **Accept** 'could spread antibiotic resistance' only if bacteria/microorganisms are mentioned 1. **Reject** 'the plants/people become resistant to antibiotics' **Ignore** 'fluorescence is easier to see' unqualified

Question	Marking guidance	Mark	Comments
03.2	Correct answer for 2 marks: 41.3(%);; Accept for 1 mark: 264 (kg per hectare increase) OR 904 ÷ 640 = 1.4125	**2** (2 × AO2)	(904 − 640) ÷ 640 × 100 = 41.25 **Accept** 41.25 or 41 for 2 marks **Reject** 29.2% (divided by 904) for 2 marks

Question	Marking guidance	Mark	Comments
03.3	1. Mean yield is 264 kg per hectare/about 41% higher, so more food is produced OR less hunger/malnutrition (humanitarian); 2. Income minus costs is higher with variety P (394 compared with 257 dollars per hectare), even though the seed costs more, so farmers are less poor; 3. Fewer insecticide sprays (2 compared with 6), so less harm to farmers' health/to other (non-target) organisms (from insecticide) OR lower insecticide costs; 4. Pod borers could become resistant to the toxin (by natural selection), so the benefit may not last; 5. The gene could pass to wild relatives (by cross-pollination/pollen) OR the toxin could harm non-target insects (eg pollinators), reducing biodiversity; 6. The seed is owned by a large/international company, so farmers cannot save their own seed and become dependent on the company OR profits go to the company (in a richer country); 7. Seed costs about three times as much (42 compared with 15 dollars per hectare), so the poorest farmers may not be able to afford it (each season); 8. Farmers chose which type to grow, so the farms may differ in other ways (eg soil, wealth, rainfall) OR only means are given, so it is not known whether the differences are significant;	**6 max** (1 × AO1) (2 × AO2) (3 × AO3)	**Max 4** if only benefits or only concerns are given **Max 5** unless at least one point uses data from Table 2 (points 1, 2, 3 or 7) 2. **Accept** a correct profit for one type only if compared with the other (257 and 394 dollars per hectare) 4. **Reject** 'pod borers become resistant because they are exposed to the toxin' without selection/a mutation 5. **Accept** 'superweeds' for gene transfer to wild relatives **Ignore** 'GM is unnatural / playing God' and 'GM food is harmful to eat' unqualified **Ignore** 'small sample' and 'only three seasons' unqualified

Gene therapy 3.8.4.1

Question	Marking guidance	Mark	Comments
04.1	1. The (functional) allele is transcribed (to mRNA) and translated (in the retina cells); 2. So the functional enzyme is made (and can catalyse its reaction); 3. The functional allele is dominant, so one copy is enough (even though the recessive alleles are still present);	**2 max** (2 × AO1)	1. **Accept** 'the allele is expressed'; ignore 'switched on' **Reject** 'the functional allele replaces/removes the recessive allele' Allele is required; penalise 'gene' for 'allele' once per answer

Question	Marking guidance	Mark	Comments
04.2	1. The functional allele is delivered only to (body/somatic) cells of the retina, not to the cells (in the ovaries) that produce eggs/gametes; 2. So all her eggs/gametes still contain the recessive allele (she is homozygous recessive);	**2** (2 × AO2)	1. **Accept** 'germ-line cells are not changed' OR 'the inserted allele is not in cells that undergo meiosis' Allele is required; penalise 'gene' for 'allele' once per answer **Ignore** 'the treatment is not inherited' unqualified

Question	Marking guidance	Mark	Comments
04.3	1. The harmful dominant allele is not removed OR is still present (in the retina cells); 2. It is still transcribed/translated/expressed, so the harmful protein is still made; 3. The condition is caused by the harmful protein (not by the lack of a functional protein), so adding a functional allele/more functional protein does not stop it;	**2 max** (2 × AO2)	3. **Accept** 'affected (heterozygous) people already have a functional/normal allele, so the condition is not caused by a lack of the functional protein' Allele is required; penalise 'gene' for 'allele' once per answer **Ignore** 'the dominant allele is always expressed' unless linked to the protein it codes for

Question	Marking guidance	Mark	Comments
04.4	1. The standard deviations/error bars (of the treated and control groups) do not overlap, so the difference is significant/(probably) not due to chance; 2. The improvement was maintained after 1 year (2.0 at 30 days and 2.2 at 1 year), so one injection has a lasting effect; 3. The control group showed little change (0.1 and 0.2), so the improvement in the treated group is due to the treatment; 4. Safety: 16 of 20/80% of treated patients had no side effect, and the raised pressure could be treated with drugs, so the treatment seems reasonably safe; 5. Against: 4 of 20/20% of treated patients had a side effect (raised pressure in the eye); 6. Against: the control group was not given a sham/dummy injection, so some of the improvement could be due to a placebo effect/patients expecting to improve; 7. Against: the standard deviation is large compared with the mean OR only means are given, so some treated patients may have improved very little OR the mean improvement is only about 2 of the 7 light levels; 8. Against: it is not known whether the retina cells will keep expressing the allele/making the enzyme after 1 year;	**5 max** (5 × AO3)	Point 1 is required for 5 marks **Max 3** from the 'against' points (5 to 8) 4. The safety point is a 'for' point and does not count towards the max 3 for 'against' points 4. Point 4 requires the idea that the side effect was treatable/manageable; '80%/16 of 20 had no side effect' alone is the converse of point 5 and does not gain point 4 1. **Reject** 'the results are significant'; the significance must be about the difference 1. **Accept** 'SDs do not overlap' **Ignore** sample size, length of investigation, repeats and statistical tests unqualified

Screening, genetic counselling and personalised medicine 3.8.4.2

Question	Marking guidance	Mark	Comments
05.1	1. Each of them has a 1 in 2/50% chance of having inherited allele **H**, because person 3 is heterozygous/**Hh**; 2. A person with allele **H** will develop condition H (because it is dominant), usually between the ages of 35 and 50; 3. Condition H cannot be cured, so a positive result could cause anxiety/depression OR they can choose not to be tested; 4. A result could help them plan for the future (eg care, work, finances); 5. A result could inform decisions about having children, eg testing embryos/a fetus for allele **H**; 6. A result may give information about relatives (eg person 3's other relatives) OR may affect insurance/employment;	**3 max** (2 × AO1) (1 × AO2)	1. **Accept** 'person 3 has one allele H and one allele h' Allele is required; penalise 'gene' for 'allele' once per answer **Ignore** 'tell them not to have children' **Ignore** 'explain how the test is done' unqualified

Question	Marking guidance	Mark	Comments
05.2	1. Allele **H** has more repeats/bases, so its fragment is longer and moves the shortest distance (from the well); 2. So the band nearest the well in person 3 is allele **H** (person 3 is affected/heterozygous **Hh**); 3. Person 4 is unaffected/**hh**, so both his bands are **h** alleles (neither is at the position of allele **H**); 4. Person 5 has the band nearest the well (the same as person 3's allele **H**), so person 5 has inherited allele **H**/is **Hh**; 5. Person 6 has person 3's lower band and one of person 4's bands, so person 6 has two **h** alleles/is **hh**;	**4 max** (2 × AO2) (2 × AO3)	Person 5 with no explanation gains no marks 1. **Accept** 'travels least far / stays nearest the well / moves more slowly' 1. **Reject** 'allele H is heavier because it is dominant' Allele is required; penalise 'gene' for 'allele' once per answer

Question	Marking guidance	Mark	Comments
05.3	0.5;	**1** (1 × AO2)	**Accept** 1 in 2 / ½ / 50% / 1 : 1 (chance) **ECF**: accept 0 only if person 6 (not person 5) was identified as having allele H in 05.2 **Reject** 0.25 or 0.75

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Question	Marking guidance	Mark	Comments
06.1	A treatment/drug (or dose) is chosen to suit a person's genotype/alleles/DNA;	**1** (1 × AO1)	**Accept** 'based on (screening) a person's genetic information' **Ignore** 'treatment designed for one person' unqualified

Question	Marking guidance	Mark	Comments
06.2	Standard chemotherapy is more effective in patients with allele **M** than in patients without allele **M**;	**1** (1 × AO3)	With chemotherapy, 45% of tumours with allele M became smaller compared with 22% without allele M (6.0 v 5.0 months). With allele M, tumours took longer to grow again with drug K (10.2 v 6.0 months), chemotherapy worked better with allele M than without it, and no side effects are given.

Question	Marking guidance	Mark	Comments
06.3	Correct answer for 2 marks: 52;; Accept for 1 mark: 260 patients without allele **M** OR 57.2 and 5.2 OR 152.4 and 100.4	**2** (2 × AO2)	400 − 140 = 260 patients without allele M; with testing they get chemotherapy (22%) instead of drug K (2%): 260 × 0.2 = 52 Patients with allele M get drug K either way (140 × 0.68 = 95.2), so they do not change the answer **Accept** 52 or 52.0

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Question	Marking guidance	Mark	Comments
06.4	1. Supported for patients with allele **M**: more tumours became smaller with drug K (68% compared with 45%) and they took longer to grow again (10.2 compared with 6.0 months); 2. Not supported for patients without allele **M**: drug K was much less effective than chemotherapy (2% compared with 22% OR 1.8 compared with 5.0 months); 3. So the statement is true only for patients whose tumour cells contain allele **M** OR the statement should say that patients must be tested first; 4. The table gives no data on survival/side effects/quality of life, so it cannot show that drug K is a better treatment overall OR only patients with advanced lung cancer were studied, so the claim cannot be applied to all lung cancers; 5. Only medians/percentages are given, with no measure of spread, so it is not known whether the differences are significant;	**3 max** (3 × AO3)	**Max 2** unless both point 1 and point 2 are given 5. **Ignore** 'no statistical test' / 'small sample' unqualified Allele is required; penalise 'gene' for 'allele' once per answer

Genetic fingerprinting 3.8.4.3

Question	Marking guidance	Mark	Comments
07.1	The number of times the base sequence is repeated at a VNTR varies between individuals;	**1** (1 × AO1)	VNTRs are found in the DNA of all nucleated cells; identical twins have the same VNTRs because they develop from one zygote.

Question	Marking guidance	Mark	Comments
07.2	Correct answer for 2 marks: 2.8×10^{-12};; Accept for 1 mark: 0.07^{10} OR $(7 \times 10^{-2})^{10}$ OR 0.000 000 000 002 8 (correct value not in standard form)	**2** (2 × AO2)	$0.07^{10} = 2.825 \times 10^{-12}$ **Accept** 2.82×10^{-12} or 3×10^{-12} for 2 marks **Reject** $0.07 \times 10 = 0.7$ for any mark

Question	Marking guidance	Mark	Comments
07.3	1. Brothers inherit their VNTRs/chromosomes from the same two parents; 2. At each site each brother receives one of only two VNTRs from each parent, so there is a 1 in 4/0.25 chance of the same pair OR brothers share about half of their VNTRs; 3. There are many different VNTRs/numbers of repeats at each site in the population, so unrelated people are unlikely to share the same pair (0.07);	**2 max** (1 × AO1) (1 × AO2)	3. Requires the idea of many different VNTRs in the population; 'unrelated people have different parents' alone does not gain point 3 **Accept** STR for VNTR throughout **Ignore** 'they are related' unqualified

Question	Marking guidance	Mark	Comments
07.4	Checking that seeds sold as a new variety really are that variety;	**1** (1 × AO1)	Plants of one variety share the same fingerprint, so a variety (and its ownership) can be identified. Inserting genes is recombinant DNA technology; copying a gene is PCR or in vivo cloning.

Question	Marking guidance	Mark	Comments
08.1	1. The samples contain only a small amount of DNA; 2. PCR makes many copies of/amplifies the (DNA fragments containing) VNTRs; 3. So there is enough DNA to produce bands that can be detected/seen;	**2 max** (2 × AO1)	**Accept** STR for VNTR **Ignore** 'PCR cuts the DNA into fragments'; reject 'PCR separates the fragments'

Question	Marking guidance	Mark	Comments
08.2	1. All the bands in sample C match the bands in sample B/the donor OR sample C has none of the bands found only in sample A/the man's own DNA; 2. So (all) the man's blood cells are now produced by the donor's (stem) cells OR none of his own blood/leukaemia cells are detected (the transplant has worked);	**2** (2 × AO2)	2. **Accept** 'the man's blood cells have his brother's DNA/VNTRs' **Ignore** 'the man's DNA has changed'

Question	Marking guidance	Mark	Comments
08.3	1. Sample D contains bands found in sample A but not in sample B (as well as all the donor's bands); 2. So some of the man's blood cells are again produced by his own cells OR some of his own (bone marrow) cells survived the treatment; 3. These could be leukaemia/cancer cells, so the leukaemia may be returning (and he may need further treatment);	**2 max** (2 × AO3)	1. **Accept** 'sample D has bands from both the man and his brother' **Ignore** 'sample D is contaminated'

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