

BIOWELSH WORKSHEET FOR WJEC GCE A LEVEL BIOLOGY
UNIT 4 – VARIATION, INHERITANCE AND OPTIONS
TOPIC 4.5 APPLIED GENETICS: WORKSHEET 1 (BW-A2-4.5-W1) MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Mark in red ink. One tick equals one mark, except in the extended response question, where a level of response scheme is used.

Write each question total in the box at the end of the question, and copy the totals onto the grid on the front cover of the worksheet. Add them to give the worksheet total out of 154.

Marking rules

Look at all of the work. Where the scheme says working is needed, the working must be seen. Mark crossed-out work if it has not been replaced. Give credit for correct, relevant answers that are not listed in the scheme.

Extended response question

Read the whole answer first. Decide which level descriptor fits the answer best, judging the overall quality. Then choose the mark within the level: the top mark when the answer matches both the content and the communication statements well, the middle mark when most of the content is there and the communication statement is partly met, and the bottom mark when only the content statements are matched.

Marking abbreviations

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt
ORA = or reverse argument
owtte = or words to that effect

Notation: / separates alternatives; { } groups alternatives within a point; words in () are not needed for the mark; underlined words are essential; (1) is one mark.

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			Any two (×1) from: - identify all the genes / find the position of each gene on the chromosomes (1) - determine the sequence of the (3 billion) base pairs (1) - store the information in databases / improve tools for analysis (1) - improve the diagnosis / treatment / understanding of genetic disorders (1) - address ethical, legal and social issues (1)	2			2		
	(b)			Smaller fragments move more easily through the pores in the gel (1) So they travel further (towards the positive electrode) in the same time (1) Reject smaller fragments have more charge	2			2		
	(c)			Sequence: T C A G G A T C C A (2) Award 1 mark if one base is wrong or missing Award 1 mark if the sequence is given in reverse order		2		2		
	(d)			Template strand: A G T C C (1) ecf from part (c)		1		1		
	(e)			Any two (×1) from: - millions of fragments are sequenced at the same time / in parallel (1) - reactions are carried out on a small scale / on a chip / with tiny volumes (1) - it is automated / computers read the sequence (1) - no separate gel is needed for each fragment (1)		2		2		
	(f)			The mutation / faulty allele causing the disease can be identified (1) Allowing a diagnosis / suitable treatment / a clinical trial / genetic counselling for the family (1)			2	2		
				Question 1 total	4	5	2	11	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)			0.25 / 1 in 4 / 25 % (1)		1		1	1	
	(b)			2 ÷ 8 × 100 = 25 (%) (1) Agrees / matches the expected 1 in 4 (1) ecf from part (a)		2		2	1	
	(c)			Embryos 1 and 5 (both needed) (1)		1		1		
	(d)			Only one cell is taken, so there is very little DNA (1) PCR makes many copies / amplifies the DNA so there is enough to test (1)		2		2		
	(e)			Any two (×1) from: - there is no cure / treatment, so knowing does not help (1) - a positive result may cause anxiety / depression (1) - the right not to know (1) - the result could affect insurance / employment / discrimination (1) - the result also reveals information about relatives who may not want to know (1)		2		2		
	(f)			For: prevents a child being born with a severe / untreatable disorder / reduces suffering / allows informed choice (1) Against: embryos carrying the disorder are destroyed, and some believe embryos have a right to life / could lead to selection for non-medical traits / false results are possible (1)			2	2		
				Question 2 total	0	8	2	10	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			Vector / carries Plasmodium from person to person (when it feeds on blood) (1) Reject causes malaria	1			1		
	(b)			The (complete) base sequence of the DNA (1) The position / location of genes on the chromosomes (1)	2			2		
	(c)	(i)		The resistance allele arose by (random) mutation (1) Chloroquine killed sensitive Plasmodium, so resistant ones survived / had a selective advantage (1) Survivors reproduced and passed on the allele, so its frequency increased (1)	1	2		3		
		(ii)		95.3 (%) (2) Award 1 mark for $(86 - 4) \div 86 \times 100$		2		2	2	
		(iii)		Without the drug there is no longer a selective advantage to the resistance allele (1) The allele may have a cost / sensitive Plasmodium reproduce more successfully, so sensitive forms increased (1)			2	2		
	(d)			Any two ($\times 1$) from: - find genes / proteins that could be targets for new drugs (1) - find antigens to develop a vaccine (1) - design primers / tests to track resistance alleles so the right drug is used (1) - genetic modification of Plasmodium to reduce pathogenicity (1)			2	2		
				Question 3 total	4	4	4	12	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			Hydrogen bonds between (complementary) bases break (1) So the DNA separates into two single strands (1) Reject breaking bonds between nucleotides / breaking phosphodiester bonds	2			2		
	(b)			Short single strand of DNA / nucleotides (about 6 to 25 bases) (1) Binds / anneals to the complementary sequence at the start of the section to be copied, so that Taq polymerase can attach (1)	2			2		
	(c)			It is thermostable / does not denature at 95 °C (so it works in every cycle) (1) Do not credit a reference to 72 °C only	1			1		
	(d)			4.29×10^{10} (2) Award 1 mark for 40×2^{30} / 42 949 672 960 / an answer not in standard form		2		2	2	
	(e)			Any two (×1) from: • use new / sterile tubes and pipette tips for every sample (1) • wear gloves / avoid touching samples, so human DNA does not contaminate them (1) • run a negative control with no DNA to check for contamination (1) • run a positive control with DNA of a known species (1) • repeat each test (1)			2	2		2
	(f)			PCR copies any DNA that the primers bind to (1) So contaminating DNA from another fish / species is amplified too, and could be sequenced instead of / as well as the sample (1)		2		2		
				Question 4 total	5	4	2	11	2	2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			Primers must be complementary to a base sequence found only in Plasmodium DNA (1) So only Plasmodium DNA is copied / mosquito DNA is not amplified (1)		2		2		
	(b)			Sample A 16 (cycles) (1) Sample B 19 (cycles) (1) Accept ± 0.5 cycle		2		2	1	
	(c)			8 (2) Award 1 mark for a difference of 3 cycles / 2^3 ecf from part (b)		2		2	2	
	(d)			Any two ($\times 1$) from: - primers / nucleotides are used up / become limiting (1) - Taq polymerase denatures after repeated heating (1) - single strands of product pair with each other instead of with primers (1)		2		2		
	(e)			Negative control: a tube with no DNA / water, to show there is no contamination / or a sample of known Plasmodium DNA, to show the PCR works (1)			1	1		1
				Question 5 total	0	8	1	9	3	1

Question				Marking details	Marks available																							
					AO1	AO2	AO3	Total	Maths	Prac																		
6	(a)			DNA is negatively charged because of its phosphate groups (1)	1			1																				
	(b)			Axes correct way round and labelled with units: x = distance moved / mm; y = $\log_{10}$ (fragment length) (1) Suitable linear scales using more than half of the grid (1) All points plotted correctly $\pm$ half a small square (1) Ruled straight line of best fit (1) Example of a full-mark answer <table><caption>Data points from the graph</caption><thead><tr><th>Distance moved / mm</th><th>$\log_{10}$ (fragment length / bp)</th></tr></thead><tbody><tr><td>8</td><td>3.7</td></tr><tr><td>18</td><td>3.5</td></tr><tr><td>28</td><td>3.3</td></tr><tr><td>35</td><td>3.2</td></tr><tr><td>42</td><td>3.0</td></tr><tr><td>48</td><td>2.9</td></tr><tr><td>55</td><td>2.7</td></tr><tr><td>65</td><td>2.4</td></tr></tbody></table>	Distance moved / mm	$\log_{10}$ (fragment length / bp)	8	3.7	18	3.5	28	3.3	35	3.2	42	3.0	48	2.9	55	2.7	65	2.4		2	2	4	4	2
Distance moved / mm	$\log_{10}$ (fragment length / bp)																											
8	3.7																											
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35	3.2																											
42	3.0																											
48	2.9																											
55	2.7																											
65	2.4																											
	(c)			1200 bp (accept 1100 to 1300) (2) Award 1 mark for a log value of 3.07 to 3.11 read from the graph ecf from the student's line		2		2	1	1																		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)			The distance moved depends on the voltage / time / gel concentration (1) So only fragments run under identical conditions can be compared (1)			2	2		2
	(e)			UV light damages eyes / skin, so wear UV-blocking goggles / a face shield (1) Some DNA stains are mutagens / toxic, so wear gloves (1) Max 1 if the hazard is given without a control			2	2		2
	(f)			They pass through the pores in the agarose gel more easily (1)	1			1		
				Question 6 total	2	4	6	12	5	7

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			Short sequence of bases repeated many times one after another (1) In non-coding DNA, with the number of repeats varying between people (1)	2			2		
	(b)			Suspect Q (1) Every band in the crime scene profile matches a band in Q in the same position (1)			2	2		
	(c)			Most bands do not match; a few bands are shared by chance / many people share some alleles (1)			1	1		
	(d)			One allele / copy of the STR is inherited from each parent (1) The two alleles often have a different number of repeats, so fragments of different lengths (1)		2		2		
	(e)			1×10^{-10} / 1 in 10^{10} (2) Award 1 mark for $(0.1)^{10}$ or 1/10 multiplied ten times		2		2	2	
	(f)			Invasion of privacy / civil liberties / the data could be hacked or misused / used for another purpose without consent (1)			1	1		
				Question 7 total	2	4	4	10	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			Male B (1)		1		1		
	(b)			Bands in the chick that match the mother were inherited from her (1) The remaining bands must have come from the father (1) Male B has all of the remaining bands / males A and C lack at least one of them (1)		1	2	3		
	(c)			The chick inherits only one of each pair of alleles from each parent (1) So about half its bands come from each parent (1)		2		2		
	(d)			Another male / a relative of the male could have the same bands by chance, especially in a small, closely related population (1)			1	1		
	(e)			To choose unrelated birds for future matings (1) To avoid inbreeding / maintain genetic diversity in the small population (1)			2	2		
				Question 8 total	0	4	5	9	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)			P reverse transcriptase (1) Q DNA polymerase (1) R restriction endonuclease / restriction enzyme (1) S (DNA) ligase (1)	4			4		
	(b)			β cells make insulin, so they contain many copies of insulin mRNA (1)		1		1		
	(c)			mRNA has had its introns removed, so the copy contains only exons / coding DNA (1) Bacteria cannot remove introns, so the protein made from the human gene would contain extra amino acids / not function (1)		2		2		
	(d)	(i)		5' G A T C 3' / GATC (1)		1		1		
		(ii)		So the sticky ends of the gene and the plasmid are complementary (1) So they can base pair / hydrogen bond before ligase joins them (1)	1	1		2		
				Question 9 total	5	5	0	10	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)			Only bacteria that have taken up a plasmid have the ampicillin resistance gene (1) So bacteria without a plasmid are killed / only transformed bacteria grow (1)		2		2		
	(b)			In white colonies the foreign gene has been inserted into the <i>lacZ</i> gene (1) So <i>lacZ</i> is interrupted / not expressed and no enzyme is made, so X-gal is not broken down (1) Blue colonies contain a plasmid without the insert, so <i>lacZ</i> works and X-gal is converted to the blue product (1)		3		3		
	(c)			26.7 (%) (2) Award 1 mark for $48 \div 180 \times 100$		2		2	2	
	(d)			The gene may be inserted the wrong way round / be incomplete / not be expressed / a different piece of DNA may have been inserted (1)			1	1		1
	(e)			The resistance genes could be transferred to bacteria (in the gut / soil) (1) Including pathogens, so infections could not be treated with that antibiotic (1)			2	2		
				Question 10 total	0	7	3	10	2	1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)			Any three (×1) from: - Ti plasmid removed from <i>A. tumefaciens</i> and cut with a restriction enzyme (1) - tumour-forming genes removed and the Bt gene inserted with (DNA) ligase (1) - plasmid returned to the bacterium, which infects plant cells (1) - the gene is inserted into a plant chromosome (1) - transformed cells grown into plants by tissue culture (1)	3			3		
	(b)			81.3 (%) (2) Accept 81.25 / 81 Award 1 mark for $(48 - 9) \div 48 \times 100$		2		2	2	
	(c)			Any two (×1) from: - less insecticide used, so fewer non-target insects killed / less pollution / lower costs (1) - less fruit damaged, so more can be sold (1) - higher yield (1) - less exposure of farmers to insecticides (1)			2	2		
	(d)			(Random) mutation gives some borers resistance (1) Bt brinjal kills non-resistant borers, so resistant ones survive and reproduce / selection pressure (1) The resistance allele is passed on and becomes more common (1)		3		3		
	(e)			Pollen could transfer the gene to wild relatives, producing herbicide-resistant weeds / more herbicide may be used, reducing biodiversity of wild plants (1)			1	1		
				Question 11 total	3	5	3	11	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	(a)			Chloride ions are not transported out of the cells (1) So water does not follow by osmosis, and the mucus is not diluted (1)	2			2		
	(b)			Less chance of an immune response / cannot cause infection / cannot insert into the genome and activate an oncogene (1)		1		1		
	(c)			Lung function in the placebo group fell steadily, by 4 % after 12 months (1) Lung function in the gene therapy group stayed about the same / fell by only 0.6 % (1)			2	2		
	(d)			Epithelial cells that took up the allele die and are replaced (1) New cells do not contain the allele / the allele is not inherited by daughter cells (1)		2		2		
	(e)			The placebo group shows the change without the therapy, so any difference is due to the therapy (1) Not knowing avoids bias / the placebo effect affecting the measurements (1)			2	2		2
	(f)			Changes would be inherited by all future generations, with unknown / unpredictable long-term effects (1)	1			1		
				Question 12 total	3	3	4	10	0	2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	(a)			118 is not a multiple of 3 (1) So the reading frame shifts after the deletion, giving different amino acids / an early stop codon (1) $118 + 212 = 330$, which is a multiple of 3 / $330 \div 3 = 110$ (1) So the reading frame is restored; the protein lacks 110 amino acids but still partly works (1)		3	1	4	2	
	(b)			3' G U C U A G A C C 5' (1) Accept written 5' to 3' as C C A G A U C U G		1		1		
	(c)			The drug acts on mRNA / pre-mRNA, not on the DNA (1) mRNA is broken down and the drug is removed, so new mRNA is made without the patch (1)		2		2		
	(d)			To identify exactly which exon(s) are deleted, because each exon skipping drug only works for particular deletions (1)		1		1		
	(e)			Stem cells divide, so the corrected gene is copied into every new muscle cell they make (1) So the effect is long lasting / repeated treatment would not be needed (1)		2		2		
				Question 13 total	0	9	1	10	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14	(a)			An undifferentiated / unspecialised cell (1) That can divide (by mitosis) and differentiate into specialised cells (1)	2			2		
	(b)			Pluripotent (1) Can become any type of cell in the body (but not the placenta) (1)	2			2		
	(c)			Less chance of rejection / an immune response, because the cells are genetically identical to the patient (1) No embryo is destroyed, so fewer ethical objections (1) Reject no rejection		2		2		
	(d)			Gives the cells a framework to attach to and form a sheet / 3D tissue of the right shape (1) It breaks down after implantation, leaving only the new tissue / it is porous so nutrients reach the cells (1)		2		2		
	(e)			Any two (×1) from: - expensive / slow to produce cells for each patient (1) - risk that the cells divide uncontrollably / form a tumour (1) - long-term effects not yet known / only small trials (1) - culture techniques are difficult / cells may not differentiate correctly (1)			2	2		
				Question 14 total	4	4	2	10	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
15				Indicative content	3	3	3	9		
				A The change in cost and the reasons for it A1 Cost fell from about 100 million dollars in 2001 to under 1000 dollars in 2021 A2 About a hundred thousand times cheaper / the fall was fastest between 2007 and 2011 A3 Sanger sequencing read one fragment at a time, using a separate reaction and gel A4 Next generation sequencing sequences millions of fragments in parallel A5 Reactions are small scale, on chips, automated and read by computers A6 Better computing / bioinformatics to assemble and analyse the sequences						
				B How genomics could change healthcare B1 Faster, more accurate diagnosis, for example of rare diseases (as in the 100K Genome Project) B2 Choosing a drug and its dose to suit a patient's genotype (pharmacogenomics), reducing side effects B3 Targeted treatment for cancers based on the mutations in a tumour B4 Identifying people at high risk so they can be screened or change their lifestyle B5 Identifying which patients are suitable for gene therapy or exon skipping B6 Genetic counselling and screening, for example carrier testing or PGD						

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				C Ethical issues C1 Who owns the genetic information / consent is needed for its use C2 Insurance companies or employers could discriminate against people with a genetic risk C3 Stored data could be hacked or used for another purpose C4 Results reveal information about relatives who have not consented C5 Some people do not want to know about a risk of an untreatable disease C6 Screening of embryos could lead to more embryos being destroyed / fears of selection for non-medical traits						
				7-9 marks Indicative content of this level is detailed information from all three lists. The candidate constructs an articulate, integrated account, correctly linking relevant points in a logical sequence. The answer fully addresses the question with no irrelevant inclusions or significant omissions. Scientific conventions and vocabulary are used appropriately and accurately.						
				4-6 marks Indicative content of this level is detailed information from two of the lists, or less detail from all three. The candidate constructs an account correctly linking some relevant points, showing some reasoning. The answer addresses the question with some omissions. Scientific conventions and vocabulary are usually used appropriately and accurately.						
				1-3 marks Indicative content of this level is some information from at least one of the lists, or a little information from more than one. The candidate makes some relevant points, showing limited reasoning. The answer addresses the question with significant omissions. Use of scientific conventions and vocabulary is limited.						

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				0 marks The candidate does not make any attempt or give a relevant answer worthy of credit.						
				Question 15 total	3	3	3	9	0	0

UNIT 4: VARIATION, INHERITANCE AND OPTIONS, TOPIC 4.5
SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	4	5	2	11	0	0
2	0	8	2	10	2	0
3	4	4	4	12	2	0
4	5	4	2	11	2	2
5	0	8	1	9	3	1
6	2	4	6	12	5	7
7	2	4	4	10	2	0
8	0	4	5	9	0	0
9	5	5	0	10	0	0
10	0	7	3	10	2	1
11	3	5	3	11	2	0
12	3	3	4	10	0	2
13	0	9	1	10	2	0
14	4	4	2	10	0	0
15	3	3	3	9	0	0
TOTAL	35	77	42	154	22	13



A Tutor Meets Tutee project

BioWelsh mark scheme BW-A2-4.5-W1 (MS). Not an official WJEC mark scheme.

