BIOWELSH WORKSHEET FOR WJEC GCE A LEVEL BIOLOGY
UNIT 4 – VARIATION, INHERITANCE AND OPTIONS
TOPIC 4.4 VARIATION AND EVOLUTION: WORKSHEET 1 (BW-A2-4.4-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 151.

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

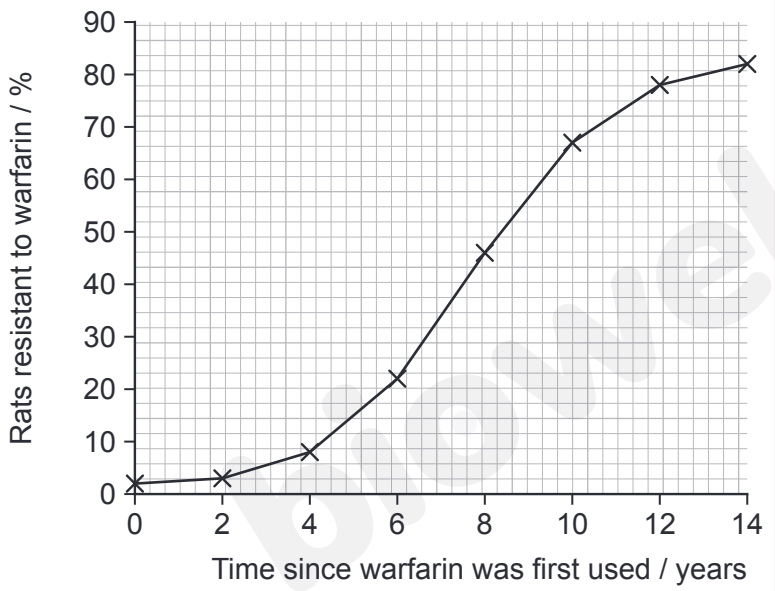
Notation: / separates alternatives; { } groups alternatives within a point; words in ( ) are not needed for the mark; underlined words are essential; (1) is one mark.

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			Discontinuous (1) Only two distinct forms / no intermediates / clear-cut categories / controlled by one gene (1)	1	1		2		
	(b)			42 (%) (1)		1		1	1	
	(c)	(i)		4.4–4.7 mm (1)		1		1		
		(ii)		Continuous variation: a range of values with intermediates / complete gradation (1) Polygenic / controlled by genes at more than one locus, each with a small effect (1) Environmental factors also affect length, for example the amount of food eaten by the larva / temperature (1)	2	1		3		
	(d)			Melanic ladybirds are active for longer / can feed and mate more in cool, cloudy conditions (1) So they have a selective advantage and are more likely to survive and reproduce, passing on the melanic allele (1) ORA for the sunny site, for example red ladybirds less likely to overheat		1	1	2		
	(e)			Crossing over (between chromatids of homologous chromosomes) in prophase I (1) Independent assortment / random orientation of homologous chromosomes at metaphase I / of chromatids at metaphase II (1)	2			2		
				Question 1 total	5	5	1	11	1	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)		2.2 (g) (1)		1		1	1	
		(ii)		2.2 (g) (1) Middle two values are 2.1 and 2.3		1		1	1	
		(iii)		0.29 (g) (3) Award 2 marks for 0.084 / $\sqrt{0.084}$ Award 1 mark for $\Sigma(x - \bar{x})^2 = 0.42$ Accept 0.290; answer to 3 or more decimal places = 2 marks		3		3	3	
	(b)			The standard deviation bars overlap (1) So the difference between the means may be due to chance / may not be significant (1)			2	2		1
	(c)			(Student's) t test (1) Compares the means of two sets of continuous (normally distributed) data (1) Reject chi-squared	1	1		2		1
	(d)			Weigh a larger number of seeds of each variety, for example 15 to 20 (1) Reject repeat unqualified			1	1		1
				Question 2 total	1	6	3	10	5	3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			Interspecific (1) Reject intraspecific	1			1		
	(b)			Any two (×1) from: • Food / named food such as seeds, nuts, acorns, fungi (1) • Nesting sites / tree holes / space to build dreys (1) • Space / territory (1) Ignore mates		2		2		
	(c)			Increase from 40 in 1998 to 700 in 2019 (1) Slow at first, fastest between about 2004 and 2013, then levelling off (1)		1	1	2		
	(d)			Less interspecific competition, so more food / nest sites for each red squirrel (1) So more red squirrels survived (the winter) and raised more young / fewer died from the virus (1)	1	1		2		
	(e)			Intraspecific competition increased as numbers rose (1) For limited food / territories, so fewer survive or breed / the population approaches the carrying capacity of the island (1)			2	2		
				Question 3 total	2	4	3	9	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			Predation / predators such as lynx, coyotes, owls or hawks (1)		1		1		
	(b)			14 (%) (2) Award 1 mark for (0.93 – 0.80) ÷ 0.93 × 100 Accept 13.98 / 14.0		2		2	1	
	(c)			Any four (×1) from: A. Variation: some hares carry the allele for a winter-brown coat (which arose by mutation) (1) B. Brown hares are camouflaged on snow-free ground / less likely to be seen and eaten by predators (1) C. So they have a selective advantage (1) D. More likely to survive and reproduce (1) E. Pass on the allele for a winter-brown coat to their offspring (1) F. Over many generations the frequency of the allele increases in the gene pool (1)	2	2		4		
	(d)			Snow still lies for most of the winter there, so white hares are camouflaged / brown hares would be conspicuous (1)			1	1		
	(e)			Any two (×1) from: • Supply of food (1) • Climate / temperature / snow cover (1) • Disease / parasites (1) • Breeding sites / shelter (1) • Human impact such as hunting or habitat loss (1)	2			2		
				Question 4 total	4	5	1	10	1	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			Axes correct way round and labelled with units: x = time since warfarin was first used / years; y = rats resistant to warfarin / % (1) Suitable linear scales using more than half of the grid (1) All points plotted correctly ± half a small square (1) Points joined with ruled straight lines (1) **Example of a full-mark answer**  		2	2	4	4	2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			Any four (×1) from: A. The resistance allele was already present / arose by mutation before warfarin was used (1) B. Warfarin killed rats without the allele / acted as a selection pressure (1) C. Resistant rats had a selective advantage / were more likely to survive (1) D. They reproduced and passed on the resistance allele (1) E. The frequency of the allele increased over many generations (1) Reject rats became resistant because they were exposed to warfarin	2	2		4		
	(c)			Without warfarin, resistance gives no advantage (1) Resistant rats are at a disadvantage / more likely to bleed or die without enough vitamin K, so they are selected against and the allele frequency falls (1)			2	2		
	(d)			Directional (selection) (1)	1			1		
				Question 5 total	3	4	4	11	4	2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			Intraspecific (competition for food / seeds) (1)		1		1		
	(b)	(i)		The distribution / curve shifts towards deeper beaks / to the right (1) The most common beak depth increases from 9.0 mm to 10.0 mm / fewer birds with beaks of 7 to 8.5 mm (1)		1	1	2		
		(ii)		6.4 (%) (2) Award 1 mark for (10.0 – 9.4) ÷ 9.4 × 100 Accept 6.38		2		2	2	
	(c)			Birds with deeper beaks could crack the large, hard seeds / obtain more food (1) So they were more likely to survive the drought / had a selective advantage (1) Beak depth is inherited, so they passed on alleles for deep beaks and the frequency of these alleles increased (1)	1	2		3		
	(d)			Directional (selection) (1)	1			1		
	(e)			The species have arisen from a common ancestor / an ancestral species that reached the islands (1) Different food on each island selected different beaks / modification by natural selection / adaptive radiation (1)	1	1		2		
				Question 6 total	3	7	1	11	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			All the alleles of all the genes in a population (at a given time) (1)	1			1		
	(b)			(Population / genetic) bottleneck (1) Accept founder effect / genetic drift	1			1		
	(c)			0.43 (3) Award 2 marks for p = 0.68 and q = 0.32 / 2 × 0.684 × 0.316 Award 1 mark for $q^2 = 0.1$ Accept 0.432 / 43%		3		3	3	
	(d)			Any three (×1) from: A. By chance, the few survivors included a carrier, so the allele was at a high frequency in the new gene pool (1) B. Bottleneck / founder effect (1) C. Genetic drift in a small population increased the frequency by chance (1) D. The island is isolated, so there is no gene flow / people marry within the population (1) Reject natural selection in favour of the allele	1	2		3		
	(e)			Any two (×1) from: • The population is small, so genetic drift changes allele frequencies (1) • Mating is not random / partners are often related (1) • There may be selection against people with achromatopsia (1) • Migration into or out of the island (1)			2	2		
				Question 7 total	3	5	2	10	3	0

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>8</td><td>(a)</td><td></td><td></td><td>Non-tasters must be tt / homozygous recessive, so their frequency is q^2; tasters may be TT or Tt, which cannot be told apart (1)</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>0.44 (2)
Award 1 mark for $q^2 = 196 \div 1000 = 0.196$</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td>(c)</td><td></td><td></td><td>493 (2)
Award 1 mark for $2pq = 2 \times 0.56 \times 0.44 = 0.49$
ecf from (b)</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td>(d)</td><td>(i)</td><td></td><td>0.6 (2)
Award 1 mark for $(2 \times 350 + 500) \div 2000$</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>360, 480 and 160 (2)
Award 1 mark for two correct
ecf from (d)(i)
Example of a full-mark answer<table><tr><th>Coat colour</th><th>Genotype</th><th>Observed number</th><th>Expected number</th></tr><tr><td>red</td><td>C^RC^R</td><td>350</td><td>360</td></tr><tr><td>roan</td><td>C^RC^W</td><td>500</td><td>480</td></tr><tr><td>white</td><td>C^WC^W</td><td>150</td><td>160</td></tr></table></td><td></td><td>2</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td></td><td>Yes, the observed numbers are close to the expected numbers, so any difference may be due to chance (1)
Accept a statistical test such as chi-squared would be needed to be sure</td><td></td><td></td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 8 total</td><td>1</td><td>8</td><td>1</td><td>10</td><td>8</td><td>0</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)			Any three (×1) from: • Large population (1) • Random mating (1) • No mutation (1) • No migration / no immigration or emigration / isolated population (1) • No selection / all genotypes equally likely to survive and reproduce (1)	3			3		
	(b)			0.6 (2) Award 1 mark for (2 × 30 + 12) ÷ 120		2		2	2	
	(c)			28.8 / 29 (2) Award 1 mark for 2pq = 2 × 0.6 × 0.4 = 0.48 ecf from (b)		2		2	2	
	(d)			Any two (×1) from: • Mating is not random / wildcats mate mostly with wildcats and hybrids with domestic cats (1) • The sample contains two partly separate gene pools / some cats are hybrids with different allele frequencies (1) • Gene flow / immigration of alleles from domestic cats (1) • Small population, so inbreeding / genetic drift (1)			2	2		
				Question 9 total	3	4	2	9	4	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)			Geographical (isolation) (1)	1			1		
	(b)			Any four (×1) from: A. The isthmus stopped gene flow between the populations (1) B. Different selection pressures in the Caribbean and the Pacific / for example temperature or food (1) C. Different mutations occurred in each population (1) D. Genetic drift (1) E. Allele frequencies / gene pools became different (over many generations) (1) F. Until they could no longer interbreed to produce fertile offspring / allopatric speciation (1)	2	2		4		
	(c)			Behavioural / pre-zygotic isolation (1) Shrimps from different oceans rarely form a mating pair (8% compared with 64%) / do not recognise each other's courtship (1)		1	1	2		
	(d)			Some pairs (8%) still formed, so they might interbreed (1) It is not known whether offspring would be produced or would be fertile / behaviour in the laboratory may differ from the wild (1)			2	2		1
				Question 10 total	3	3	3	9	0	1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)			They are active at different times of year / seasonal isolation (1) They mate on different fruit, so rarely meet / behavioural isolation (1)		2		2		
	(b)			Sympatric, because the two groups live in the same area / no geographical barrier (1)		1		1		
	(c)			Little or no gene flow between the two groups (1) Different selection pressures (for example fruit ripening time or fruit chemistry) / different mutations / genetic drift change allele frequencies in each gene pool (1) Until the groups can no longer interbreed to produce fertile offspring (1)	1	2		3		

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td>(d)</td><td></td><td></td><td>Behavioural, pre-zygotic (1)
Gametic, pre-zygotic (1)
Hybrid inviability, post-zygotic (1)
Morphological / mechanical, pre-zygotic (1)
Both entries in a row needed for each mark

Example of a full-mark answer
<table><tr><th>Example</th><th>Isolating mechanism</th><th>Pre-zygotic or post-zygotic</th></tr><tr><td>two frog species with different mating calls</td><td>behavioural</td><td>pre-zygotic</td></tr><tr><td>sea urchin sperm cannot bind to the eggs of another species</td><td>gametic</td><td>pre-zygotic</td></tr><tr><td>hybrid embryos of two toad species die before hatching</td><td>hybrid inviability</td><td>post-zygotic</td></tr><tr><td>two orchids whose flowers only fit pollinating insects of different sizes</td><td>morphological (mechanical)</td><td>pre-zygotic</td></tr></table></td><td>4</td><td></td><td></td><td>4</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 11 total</td><td>5</td><td>5</td><td>0</td><td>10</td><td>0</td><td>0</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	(a)			9 in each (1)	1			1		
	(b)			The 9 radish and 9 cabbage chromosomes are not homologous (1) So they cannot pair / form bivalents in prophase I of meiosis (1) So viable gametes cannot be produced (1)	1	2		3		
	(c)			The chromosomes replicated but the cell did not divide / no cytokinesis / non-disjunction of every chromosome (1) So every chromosome now has an identical partner / homologous pairs (1) So pairing in meiosis is normal and viable gametes with 18 chromosomes are produced (1)	1	2		3		
	(d)			It cannot interbreed with either parent to produce fertile offspring (1) Offspring with radish have 27 chromosomes (18 + 9), so the 9 cabbage chromosomes have no partners and meiosis fails (1)		1	1	2	1	
				Question 12 total	3	5	1	9	1	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	(a)			Any two (×1) from: • Organisms produce more offspring than survive (1) • Population sizes stay roughly constant (1) • Resources are limited (1) • Individuals in a population vary, and some variation is inherited (1)	2			2		
	(b)			The fossils show a gradual series of changes over time / hind limbs become smaller (1) Similar (bone) structures suggest a common ancestor / whales descended from land mammals (1) Older fossils lived on land and younger ones in the sea, showing descent with modification (1)		1	2	3		
	(c)			Variation in the size of hind limbs (1) In water, individuals with smaller hind limbs were more streamlined / swam faster / had a selective advantage (1) So they survived, reproduced and passed on their alleles, and over many generations the frequency of these alleles increased (1)	1	2		3		
	(d)			Fossils only form in rare conditions / most remains decay / many fossils have been destroyed by erosion or have not been found (1)			1	1		
				Question 13 total	3	3	3	9	0	0

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>14</td><td>(a)</td><td></td><td></td><td>Mark out the area with tape measures / a grid and use random numbers (from a table or calculator) to give coordinates (1)
Measure the longest leaf of the plant nearest each coordinate (1)</td><td></td><td></td><td>2</td><td>2</td><td></td><td>2</td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>Any two (×1) from:
• Leaves at the same stage / fully expanded / the longest leaf of each plant (1)
• Same time of year / day (1)
• Same measuring method, blade only, to the nearest mm (1)
• Both areas in the same field / same soil / same slope and aspect (1)
• Same number of plants in each area (1)</td><td></td><td>2</td><td></td><td>2</td><td></td><td>2</td></tr>
<tr><td></td><td>(c)</td><td></td><td></td><td>Mean 61.8 (1)
s^2 = 50.7 / 50.74 (1)
Example of a full-mark answer
<table>
<tr><th></th><th>Footpath</th><th>Grassland</th></tr>
<tr><td>number of leaves, n</td><td>15</td><td>15</td></tr>
<tr><td>mean length, $\bar{x}$ / mm</td><td>61.8</td><td>95.0</td></tr>
<tr><td>$\Sigma(x - \bar{x})^2$</td><td>710.4</td><td>1302.0</td></tr>
<tr><td>$s^2 = \Sigma(x - \bar{x})^2 \div (n - 1)$</td><td>50.74</td><td>93.0</td></tr>
</table></td><td></td><td>2</td><td></td><td>2</td><td>2</td><td>1</td></tr>
<tr><td></td><td>(d)</td><td></td><td></td><td>10.7 (2)
Award 1 mark for 33.2 ÷ √(6.2 + 3.38) / 33.2 ÷ 3.10
ecf from (c)</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td>(e)</td><td></td><td></td><td>There is no significant difference between the mean length of plantain leaves on the footpath and in the grassland (1)
Must include significant and mean</td><td></td><td>1</td><td></td><td>1</td><td></td><td>1</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(f)			28 degrees of freedom (1) t is greater than the critical value of 2.05 (and 2.76), so reject the null hypothesis (1) There is a significant difference between the means / the probability that the difference is due to chance is less than 5% (1%) (1) ecf from (d)			3	3	1	2
	(g)			Could be either: trampling may damage leaves / change growth (environmental), or may select for plants with short leaves (genetic) (1) Grow seeds or cuttings from both areas in the same conditions and compare leaf length; a difference that remains is genetic (1)			2	2		1
				Question 14 total	0	7	7	14	5	9

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
15				**Indicative content**	3	3	3	9		
				A Natural selection of colour patterns A1 Variation in colour pattern exists / arose by mutation A2 Predators such as birds or snakes act as a selection pressure A3 On the coastal side, plain orange-brown salamanders resemble the poisonous newt, so predators avoid them (mimicry) A4 On the inland side, blotched salamanders are camouflaged, so they are less likely to be seen and eaten A5 Individuals with the advantageous pattern survive and reproduce, passing on their alleles A6 Over many generations the frequency of these alleles increases on each side						
				B Isolation and changes to the gene pools B1 The hot, dry valley is a geographical barrier, so there is no gene flow directly across it B2 The two chains of populations spread south separately B3 Different selection pressures on each side B4 Different mutations and genetic drift in each population B5 Allele frequencies / gene pools diverge over many generations B6 When the two forms meet at E they no longer interbreed successfully: reproductive isolation, for example behavioural, or hybrids that survive less well (post-zygotic) B7 This is allopatric divergence						

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				C Are they separate species? C1 A species is a group of organisms that can interbreed to produce fertile offspring C2 At E the two forms rarely interbreed and hybrids are less successful, so they behave as separate species C3 But alleles can still flow between them through the chain of neighbouring populations round the valley C4 Some hybrids are produced, and it is not stated whether they are fertile C5 The situation shows speciation in progress, so the species definition is hard to apply C6 DNA comparison or breeding tests of hybrid fertility would help decide						
				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 4.4

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	5	5	1	11	1	0
2	1	6	3	10	5	3
3	2	4	3	9	0	0
4	4	5	1	10	1	0
5	3	4	4	11	4	2
6	3	7	1	11	2	0
7	3	5	2	10	3	0
8	1	8	1	10	8	0
9	3	4	2	9	4	0
10	3	3	3	9	0	1
11	5	5	0	10	0	0
12	3	5	1	9	1	0
13	3	3	3	9	0	0
14	0	7	7	14	5	9
15	3	3	3	9	0	0
TOTAL	**42**	**74**	**35**	**151**	**34**	**15**