Model Answers: Hard

1a

a) i) The type of cell division represented in Fig. 1 is…

- Meiosis; [1 mark]

a) ii) The ways in which meiosis contributes to phenotypic variation:

Any **four** of the following:

- (Meiosis) leads to genetic variation (which produces phenotypic variation); [1 mark]
- (Through) independent assortment of homologous chromosomes (during metaphase I); [1 mark]
- The random alignment of chromosomes results in different chromosome/allele combinations (in each gamete); [1 mark]
- Crossing over of non-sister chromatids (during prophase I); [1 mark]
- The exchange of genetic material (between non-sister chromatids) leads to new allele combinations on chromosomes **OR** it can break linkages between genes; [1 mark]

[Total: 5 marks]

One factor that can produce phenotypic variation between organisms of the same species is genetic variation. Meiosis can contribute to this by reshuffling existing genes in the genotype of an organism through independent assortment and crossing over. This ensures that each gamete (and therefore potential offspring) receives a different combination of alleles that results in differences in the phenotype.

1b

b) The variation in height between the tomato plants was due to…..

Any **two** of the following:

- The height of the tomato plants were affected by environmental factors / nutrient composition of the soil; [1 mark]
- Plants growing in nutrient poor soil were not able to grow to their full potential size (determined by their genotype) **OR** plants growing in nutrient rich soil were able to reach their full potential size; [1 mark]
- Mutations of the gene coding for height; [1 mark]

[Total: 2 marks]

1c

c) This observation can be explained as follows:

- The (short) height of the parent plants were affected by environmental factors / nutrient composition of soil (type **B**); [1 mark]
- This cannot be inherited, as it did not affect/change the DNA/genes/(T-)alleles; [1 mark]
- The offspring was able to reach their full (genetic) potential size due to the presence of sufficient nutrients; [1 mark]

[Total: 3 marks]

2a

a) i) The stage of meiosis where single chromosomes line up on the equator is…

- Metaphase <u>II/2</u>; [1 mark]

a) ii) The events taking place during anaphase I of meiosis are…

Any **two** of the following:

- Spindle (fibres)/microtubules contract/shorten; [1 mark]
- Chromosome(s) are pulled to poles/centrioles; [1 mark]
- Centromeres are pulled first; [1 mark]
- Homologous chromosomes/pair (of chromosomes)/bivalent is separated/pulled apart; [1 mark]

a) iii) Crossing over during meiosis leads to genetic variation because...

Any **two** of the following:

- Non-sister chromatids...; [1 mark]
- ...Exchange alleles/sections of DNA; [1 mark]
- Chiasmata form; [1 mark]
- (Giving) new/different allele combinations **OR** leading to recombination; [1 mark]

[Total: 5 marks]

ii) Remember that spindle fibres **shorten** in order to have the **effect** of pulling the chromosomes. It is therefore important to say that they 'contract/shorten' in marking point 1 before going on to describe the effect of this in marking point 2

For parts (ii) and (iii) you need to be really careful with your use of scientific language. Look out for the underlined words because these are the words that are essential in order to gain marks. Avoid being too vague with your language as this is a very common way to drop marks in an exam.

2b

b) i) The results in Table 1 show that the two populations differ in their resistance to mesotrione because...

Any **two** of the following:

- Test group takes longer **OR** test group degrades mesotrione more slowly; [1 mark]
- So test group is less resistant / fewer have resistance; [1 mark]
- Test group standard deviation is larger **SO** (population) is more variable; [1 mark]

b) ii) This example of genetic variation is important for natural selection in water hemp populations because...

Any **two** of the following:

- The hemp can adapt/evolve / survive over the long term; [1 mark]
- Resistant/mutant plants have a selective advantage...; [1 mark]
- ...In areas where mesotrione is used; [1 mark]
- Resistant/mutant plants survive and reproduce; [1 mark]

b) iii) The benefit of this to a farmer is that...

Any **one** of the following:

- This lets the farmer choose a different / the most effective herbicide; [1 mark]
- Less money is wasted due to choosing the wrong herbicide / a reduced crop yield; [1 mark]

[Total: 5 marks]

i) You need to make sure that your points for this question are comparative; you shouldn't refer to either population in isolation. You can indicate to an examiner that you are making comparisons by using terms such as 'longer', 'more', less', and 'fewer.

Remember that with an 'explain' question you can't just quote the data from the table, you need to say **why** the data is the way it is.

iii) Remember that water hemp is the weed, not the crop.

2c

c) i) The value of *t* can be calculated as follows…

- Numerator working = 17.4; [1 mark]
- Denominator working = $\sqrt{3.76 + 0.91}$ **OR** $\sqrt{4.67}$ **OR** 2.16; [1 mark]

Marks are awarded for the working and not for the final answer.

c) ii) The null hypothesis should be…

Any **two** of the following:

- Rejected because ***t***/calculated value is greater than 2.23/critical value; [1 mark]
- The probability of the result occurring by chance is less than 0.05/5 % **OR** $p < 0.05$; [1 mark]
- There is a significant difference between the means/test and control populations; [1 mark]

[Total: 4 marks]

Remember to **show your working** (as instructed in the question!). Both of the marks here are given for correctly calculating the numerator and denominator within the working rather than for the value of *t* itself, so just writing down the final answer will not gain any marks.

population of water hemp	mean time for 50% of absorbed mesotrione to degrade / hours	standard deviation
test	27.5	4.75
control	10.1	2.34

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

Key
$\bar{x}$ = mean
s = standard deviation
n_1 = 6 (number of readings for test population)
n_2 = 6 (number of readings for control population)

$$t = \frac{27.5 - 10.1}{\sqrt{\frac{4.75^2}{6} + \frac{2.34^2}{6}}}$$

$$t = \frac{17.4}{\sqrt{3.76 + 0.91}}$$ [1 mark] [1 mark]

$$t = \underline{8.05}$$

3a

(a) The purpose of the statistical test called the *t*-test is:

- To compare the <u>means</u> (of two sets of data); [1 mark]
- To determine if they are <u>significantly different</u> or not / to determine a <u>significant difference</u>; [1 mark]

[Total: 2 marks]

When discussing in the context of statistical tests you need to use the term 'statistically different' and not just 'the data is significant'.

3b

(b)

(i) The mean of the students' handspans is

- No anomalies / outliers, so can divide by 10
- 20.3 + 21.1 + 22.2 + 19.5 + 20.0 + 21.3 + 18.6 + 23.3 + 19.8 + 19.9 = 206.0; [1 mark]
- 206 ÷ 10 students = 20.6 cm; [1 mark]

(ii) The completed table looks like:

Student	Hand span / cm	$x-\bar{x}$

Ali	20.3	-0.3
Billy	21.1	0.5
Caleb	22.2	1.6
Dylan	19.5	-1.1
Eli	20.0	-0.6
Faaz	21.3	0.7
Gabe	18.6	-2.0
Harry	23.3	2.7
Ismail	19.8	-0.8
Joe	19.9	-0.7
Mean $\bar{x}$ (from part (i)	**20.6**	**Σ(x-x**

[1 mark] for the the third column

[1 mark] for the final column]

[1 mark] for the correct value of $(x-\bar{x})^2$

(iii) The standard deviation is calculated as follows:

- ; [1 mark]
- = 1.39; [1 mark]

[Total: 7 marks]

x = The hand span

$\bar{x}$ = The mean from part (i): 20.6

Student	Hand span / cm	x-x̄	$(x-\bar{x})^2$
Ali	20.3	-0.3 squared	0.09
Billy	21.1	0.5	0.25
Caleb	22.2	1.6	2.56
Dylan	19.5	-1.1	1.21
Eli	20.0	-0.6	0.36
Faaz	21.3	0.7	0.49
Gabe	18.6	-2.0	4.00
Harry	23.3	2.7	7.29
Ismail	19.8	-0.8	0.64
Joe	19.9	-0.7	0.49
Mean x̄ (from part (i)	**20.6**		**$\Sigma(x-\bar{x})^2$ = 17.38**

- $S = \sqrt{\dfrac{17.38}{(10-1)}}$; [1 mark]
- = 1.39; [1 mark]

10 sets of results

3c

(c) The null hypothesis for this investigation would be:

- There is no significant difference between two means of countries A and B; [1 mark]
- (And that) any differences seen are due to chance; [1 mark]

[Total: 2 marks]

3d

(d) The calculation of t is as follows:

- Numerator: difference in means = 21.03 - 19.94 = 1.09; [1 mark]

- Denominator: squares of SDs divided by sample sizes = ; [1 mark]
- Value of t = 1.09 ÷ 0.585 = 1.86; [1 mark]

[Total: 3 marks]

	Country A	Country B
Mean / cm	$\bar{x}_2 = 19.94$	$\bar{x}_1 = 21.03$
Standard deviation	$S_2 = 0.756$	$S_1 = 1.687$
Sample size	$n_2 = 10$	$n_1 = 10$

Use the formula $t = \dfrac{\bar{x}_1 - \bar{x}_2}{\sqrt{\dfrac{S_1^2}{n_1} + \dfrac{S_2^2}{n_2}}}$

$$= \frac{21.03 - 19.94}{\sqrt{\dfrac{1.687^2}{10} + \dfrac{0.756^2}{10}}}$$

$$= \frac{1.09}{0.585}$$ [1 mark] [1 mark]

$$= \underline{1.86}$$ [1 mark]

[Total: 3 marks]

3e

(e) The null hypothesis can be:

- Accepted; [1 mark]
- 1.86 < 2.26 for 9 degrees of freedom at 5% confidence; [1 mark]
- The probability that the results are due to chance is high / the differences between the means is not significant; [1 mark]

Allow error carried forward from part (d)'s numerical value

[Total: 3 marks]

The *t* value of 1.86 is below the critical value of 2.26 for 9 degrees of freedom at a 5% confidence level. The reason we used 9 degrees of freedom is because there are 10 data sets, we then subtract 1 from this to work out the degrees of freedom. Generally, unless you are asked otherwise, the critical value is taken at 5% confidence level, which means there is a 5% risk of concluding that a result is significant when it was actually due to chance.