17.1 Variation

Question Paper

Course	CIE A Level Biology
Section	17. Selection & Evolution
Topic	17.1 Variation
Difficulty	Hard

Time allowed: 50

Score: /41

Percentage: /100

Question 1a

Fig. 1 shows a type of cell division occurring in the reproductive organs of humans.

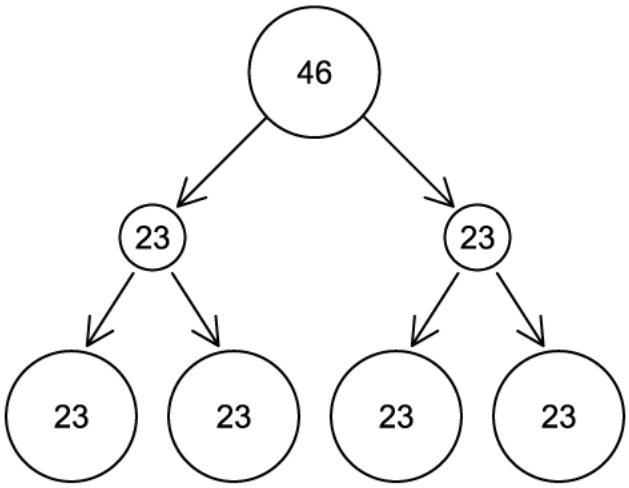

Fig. 1

(i)

Identify the type of cell division illustrated in Fig. 1.

[1]

(ii)

Explain how the type of cell division identified in part (i) contributes to variation in the phenotype of the resulting offspring.

[4]

[5 marks]

Question 1b

Tall tomato plants are produced by the presence of a dominant allele **T**. Two homozygous tall plants were crossed and seeds from this cross were planted in soils with different nutrient compositions. The mean height of each group of tomato plants was calculated and the results are shown in Table 1.

Table 1

Soil type	Mean height / cm
A	35
B	12
C	26
D	40

Suggest reasons for the variation in height that was observed in the tomato plants.

[2 marks]

Question 1c

Seeds from the tomato plants grown in soil type **B** were taken and planted in soil type **D** where they reached an average height of 42 cm.

Explain this observation.

[3 marks]

Question 2a

Meiosis is one process that contributes to genetic variation.

(i)

State precisely the stage of meiosis where single chromosomes line up on the equator.

[1]

(ii)

Outline the events taking place during anaphase I of meiosis.

[2]

(iii)

Describe how crossing over during meiosis leads to genetic variation.

[2]

[5 marks]

Question 2b

Mutation also causes genetic variation. Some populations of water hemp, *Amaranthus tuberculatus*, have evolved herbicide resistance as a result of a mutation. This is a problem for farmers as water hemp grows in crop fields, lowering productivity.

Two populations of water hemp were tested for resistance to the herbicide mesotrione. One was a population known to be resistant (control) and the other was a test population, whose resistance was unknown.

- Leaves were removed and immersed in a radioactively labelled solution of mesotrione.
- The leaves absorbed some mesotrione and became radioactive.
- Resistant leaves are able to degrade mesotrione by metabolism.
- The time for 50 % of absorbed mesotrione to degrade was calculated by measuring the radioactivity of the leaves.

The results are shown in Table 1.

Table 1

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

(i)
Explain how the results in Table 1 show that the two populations differ in their resistance to mesotrione.

[2]

(ii)

Explain why this example of genetic variation is important for natural selection in water hemp populations.

[2]

(iii)

Farmers can send in a sample of leaves of water hemp from their fields to a laboratory to be tested for resistance to mesotrione or other herbicides.

Suggest the benefit of this to a farmer.

[1]

[5 marks]

Question 2c

The null hypothesis states there is no significant difference between the mean times for 50 % of absorbed mesotrione to degrade in the two populations.

A *t*-test can be carried out to compare these two means. The critical value for ***t*** at the $p = 0.05$ significance level is 2.23.

(i)
Use the formula in Fig. 1 to calculate the value of ***t***.

Show your working.

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

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)

Fig. 1

[2]

(ii)
Use your calculated value of ***t*** to explain whether the null hypothesis should be accepted or rejected.

[2]

[4 marks]

Question 3a

The ***t*-test** is a statistical test used to compare two sets of biological data.

State the purpose of *t*-test.

[2 marks]

Question 3b

A number of boy students in a school measured their maximum handspan using a ruler as shown in Fig. 1.

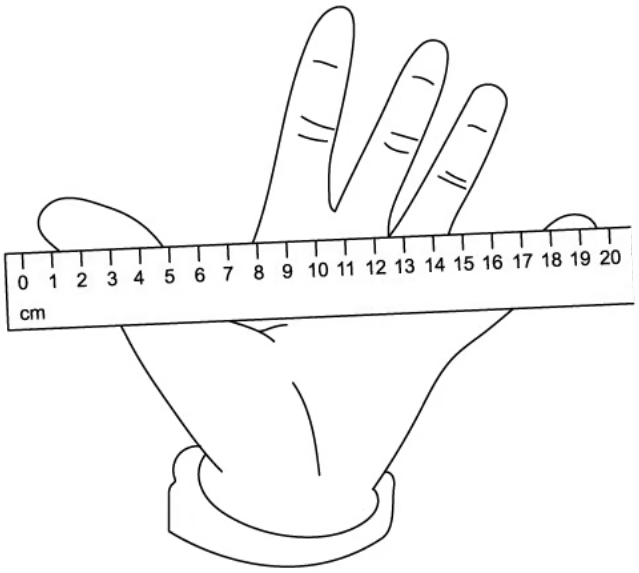

Fig. 1

Table 1 shows their class data:

Table 1

Student	Hand span / cm
Ali	20.3
Billy	21.1
Caleb	22.2
Dylan	19.5
Eli	20.0
Faaz	21.3
Gabe	18.6
Harry	23.3
Ismail	19.8
Joe	19.9

(i)

Calculate the mean value $\bar{x}$ of the students' handspans.

[2]

(ii)

Use Table 2 below to calculate and sum the values of $(x-\bar{x})^2$

Student	Hand span / cm	$x-\bar{x}$	$(x-\bar{x})^2$
Ali	20.3		

Billy	21.1		
Caleb	22.2		
Dylan	19.5		
Eli	20.0		
Faaz	21.3		
Gabe	18.6		
Harry	23.3		
Ismail	19.8		
Joe	19.9		
Mean $\bar{x}$ (from part (i)			

[3]

(iii)

From the values you have found in Table 2, calculate the standard deviation S using the formula below.

$$s = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$$

[2]

[7 marks]

Question 3c

In a linked experiment, groups of 10 male students from two different countries (Countries A and B) also took part in this experiment.

All the boys taking part were of the same age group as the boys in Table 1 and also measured their maximum hand spans.

Their data calculated out as follows:

Table 2

	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	$n_2 = 10$	$n_1 = 10$

State a null hypothesis for this investigation.

[2 marks]

Question 3d

From the data described in part (c), calculate the t value between the data from Country A and Country B.

The formula for calculating *t* is as follows:

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

[3 marks]

Question 3e

Table 3 shows a table of critical values for the *t*-test carried out in parts (c) and (d).

Table 3

Degrees of freedom	Value of *t*			
1	6.31	12.7	63.7	63.6
2	2.92	4.30	9.93	31.6
3	2.35	3.18	5.84	12.9
4	2.13	2.78	4.60	8.61
5	2.02	2.57	4.03	6.87
6	1.94	2.45	3.71	5.96
7	1.90	2.37	3.50	5.41
8	1.86	2.31	3.36	5.04
9	1.83	2.26	3.25	4.78
10	1.81	2.23	3.17	4.59
Probability that chance could have produced this value of *t*	0.10	0.05	0.01	0.001
Confidence level	10%	5%	1%	0.1%

Use the value of *t* that you calculated in part (d) to either reject or accept your null hypothesis from part (c).

Give a reason for your decision.

[3 marks]