1. Nov/2018/Paper_41/No.3

(a) 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.

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.... [2]

(iii) Describe how crossing over during meiosis leads to genetic variation.

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.... [2]

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 3.1.

Table 3.1

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

(b) **(i)** Explain how the results in Table 3.1 show that the two populations differ in their resistance to mesotrione.

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.... [2]

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

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.... [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.

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.... [1]

(c) 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. 3.1 to calculate the value of t.

Show your working.

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

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)

Fig. 3.1

t = ... [2]

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

accept or reject ....

explanation ....

....

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....[2]

[Total: 14]

2. Nov/2018/Paper_41/No.4

The Hawaiian archipelago is a group of volcanic islands in the Pacific ocean.

Fig. 4.1 shows the relative locations of five of these islands.

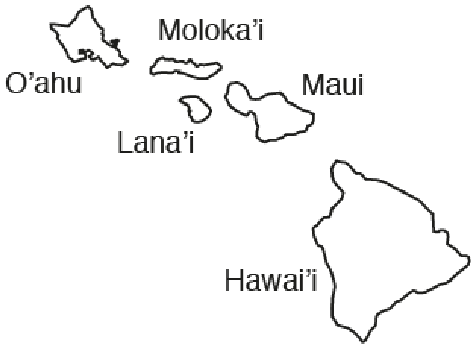

Fig. 4.1

Table 4.1 shows the size and age of these five islands and the total number of *Mecyclothorax* ground beetle species and their species density, on each island.

Data for the island of Maui is shown as two distinct regions, West and Haleakalā. This is because they formed at different times from two separate volcanoes.

Table 4.1

island	area / km^2	age of island / million years	total number of *Mecyclothorax* species	species density / number of species per km^2
Hawai'i	10433	0.4	30	0.003
Lāna'i	364	1.3	3	0.008
Maui (West)	443	1.3	27	0.061
Maui (Haleakalā)	1440	1.1	116	0.081
Moloka'i	673	1.9 – 1.8	43	0.064
O'ahu	1545	3.7 – 2.6	20	....

Fig. 4.2 shows a ground beetle of the genus *Mecyclothorax*. All the beetle species of this genus on the Hawaiian archipelago form a monophyletic group, descended from one original colonising species that reached Maui from Australia.

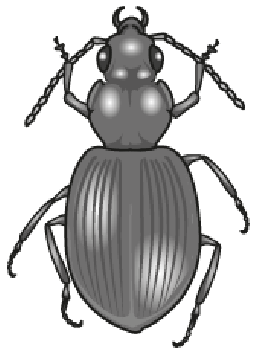

Fig. 4.2

(a) **(i)** Complete Table 4.1 by calculating the density of *Mecyclothorax* beetle species on the island of O'ahu. [1]

(ii) Use Table 4.1 to explain why the island of Hawai'i has the lowest density of *Mecyclothorax* beetle species.

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.... [2]

(iii) Use Fig. 4.1 and Table 4.1 to suggest why O'ahu has a lower number of *Mecyclothorax* beetle species than Moloka'i.

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.... [2]

(b) The rate of speciation of *Mecyclothorax* beetles on the slopes of the volcano Haleakalā, on Maui, is the highest recorded for any genus or location on earth.

The volcano last erupted 400 years ago. This produced lava flows which cut through ancient forest and vegetation, dividing it into many separate microhabitats.

Explain how the large number of *Mecyclothorax* beetle species on Haleakalā developed.

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....[4]

[Total: 9]

3. Nov/2018/Paper_43/No.3

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4. Nov/2018/Paper_43/No.4

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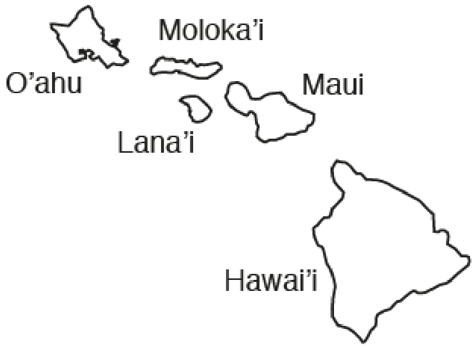

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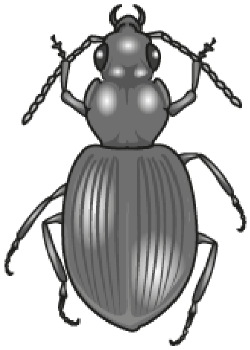

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