

Model Answers: Hard

1a

(a) (i) The density of *Mecyclothorax* beetle species on the island of O'ahu is...

- 0.013; [1 mark]

(a) (ii) The island of Hawai'i has the lowest density of *Mecyclothorax* beetle species because...Any **two** of the following:

- Hawai'i is youngest island / formed only 0.4 million years ago; [1 mark]
- Less time for *Mecyclothorax* to colonise / undergo speciation; [1 mark]
- Hawai'i has large area so density/number of species per km² is low; [1 mark]
- Hawai'i has a low habitat diversity; [1 mark]

Accept answers relating to Hawai'i being at an early stage of succession for marking point 4.(a) (iii) O'ahu has a lower number of *Mecyclothorax* beetle species than Moloka'i because...Any **two** of the following:

- O'ahu is further away from Maui (than Moloka'i); [1 mark]
- Fewer *Mecyclothorax* (individuals/species) reached O'ahu; [1 mark]
- O'ahu was colonised later; [1 mark]
- There has been less time for speciation (on O'ahu); [1 mark]

[Total: 5 marks]

(i) You need to make sure your answer is rounded to the same number of decimal places as the figures for the other islands.

island	area / km ²	age of island / million years	total number of <i>Mecyclothorax</i> 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

$$\begin{aligned} \text{Species density of O'ahu} &= \frac{\text{Number of species}}{\text{area / km}^2} \\ &= \frac{20}{1545} = \underline{0.013} \text{ [1 mark]} \end{aligned}$$

(ii) The question tells us that the beetles in this archipelago all descend from an ancestral species that originally colonised Maui from Australia. The beetles would have gradually colonised the islands surrounding Maui and would have **colonised the older islands longer ago** than the younger islands. The older islands have therefore had **more time to be**

colonised by more species of beetle, as well as having **more time for the process of speciation** to occur and give rise to more new species.

(iii) This question contains similar ideas to part ii) but relates to distance rather than age of the islands. Having read the question stem you will be aware that **Maui** was the island **originally colonised** by the beetles from Australia. This means that within the archipelago the beetles all came from Maui, so the islands **closer** to Maui would have been **colonised first**. Just as in part ii) this means that there has been **more time for different species to colonise** Molokai'i than O'ahu, as well as **more time for speciation** to give rise to new species on Molokai'i.

1b

(b) The large number of *Mecyclothorax* beetle species on Haleakalā developed by...

Any **four** of the following:

- Allopatric speciation; [1 mark]
- Geographical isolation / population became divided; [1 mark]
- Different mutations/alleles in different populations; [1 mark]
- Different selection pressures (act on different populations); [1 mark]
- No gene flow/interbreeding between populations; [1 mark]
- Genetic differences accumulated; [1 mark]
- Natural selection occurred; [1 mark]
- Genetic drift / founder effect; [1 mark]

[Total: 4 marks]

Make sure that you are confident applying the principles of speciation to different real-life scenarios that an exam could present you with.

Note that genetic drift is a **random process** that occurs when allele frequencies change purely due to chance, and is not the result of natural selection.

2a

(a) Wisdom teeth became vestigial structures in *Homo sapiens* because:

Any **two** from the following:

- There was a change in diet for *Homo sapiens* **OR** a described example of change e.g. *Homo sapiens* eat less (raw) plant material / use fire/heat to cook food/plant material / *Homo sapiens* eat more processed food; [1 mark]
- (This diet) requires less chewing so the size of the jaw decreased / smaller jaw size were selected for **OR** less / smaller molars were selected for; [1 mark]

[Total: 2 marks]

The raw plant based diet of early humans required a robust jaw and large teeth, especially molars, in order to chew the plant roughage. Since humans are unable to digest cellulose, they would have had to consume large amounts of plant material to gain enough energy and nutrients for survival. *Homo habilis* did not discover fire, so they were unable to cook food in order to make plant material easier to chew. A third pair of molars came in very handy to do this!

2b

(b) Humans still have wisdom teeth because...

Any **one** of the following:

- This suggests that humans share a common ancestor with organisms that still use

the third molars (from which it was inherited); [1 mark]

- The presence of wisdom teeth does not significantly harm humans so they are not selected against (and therefore persists); [1 mark]

[Total: 1 mark]

2c

(c) (i) The possible fate of wisdom teeth in future human populations could be...

- Wisdom teeth may reduce in size / disappear from future populations; [1 mark]

(c) (ii) A reason for this would be...

- There is no selective advantage to having wisdom teeth / they will not be selected for **OR** they could be selected against in future generations (due to their negative impact on oral health); [1 mark]

[Total: 2 marks]

If it was advantageous for modern humans to have wisdom teeth, then the alleles for these teeth would have a greater chance of being passed down to future generations. Since wisdom teeth serve no purpose in modern humans and in some cases may even have a negative impact on health, there is no selection pressure for them and we would expect to see them becoming less common in future populations.

2d

(d) Allopatric and sympatric speciation have the following characteristics...

- Both lead to the formation of new species from pre-existing ones over time **OR** both lead to changes to gene pools from generation to generation; [1 mark]
- Genetic isolation / no genetic exchange/flow (between new population and pre-existing population) must occur for both types of speciation to occur; [1 mark]
- Allopatric speciation involves a geographical barrier/isolation between two populations **WHILE** sympatric speciation takes place with no geographical barrier/isolation between two populations **OR** populations experience ecological/behavioural separation; [1 mark]

[Total: 3 marks]

Make sure that you cover both similarities **and** differences between the two types of speciation in order to gain full marks for this question.

3a

(a) Scientists could distinguish if the lizards are members of the same species by...

- Breeding individuals together / cross breeding individuals; [1 mark]
- Members of the same species can produce fertile offspring; [1 mark]

[Total: 2 marks]

If fertile offspring is produced it means that the individuals still belong to the same species. Note that it would not be enough to simply state that offspring is produced; the offspring must be able to reproduce themselves.

3b

(b) Speciation may have occurred because:

Any **four** of the following:

- There is isolation of two populations/allopatric speciation due to segmentation of the forest patches; [1 mark]
- Variation within the dwarf gecko species is already present due to mutations (in the

DNA); [1 mark]

- Different environmental conditions/selection pressures exist for each separated group **OR** selection of different features takes place in each population; [1 mark]
- Favourable alleles are passed onto offspring; [1 mark]
- Gene pools are separated **OR** no interbreeding; [1 mark]

[Total: 4 marks]

Populations can become separated either by a physical barrier, allopatric speciation, as is the case here or if members decide on different habits (food sources, mating locations, etc) otherwise known as sympatric speciation. The groups that form will face different selection pressures because the environment within which they live will differ in food sources, nesting sites, predators, etc which results in different traits being more suitable for the environment.

3c

(c) Colour patterns displayed by lizard species help to maintain them as separate species as...

- (It) allows selection of a mate / mating partners can be identified; [1 mark]
- Keeps the gene pool separate / prevents interbreeding/gene flow; [1 mark]

[Total: 2 marks]

For successful mating, animal species must be able to identify one another but also members of the opposite gender. If the species are similar in most other respects, as the question states, then we can assume that the colour patterns help the lizard species identify each other.

3d

(d) Two species of maggots arose by sympatric speciation because...

Any **four** of the following:

- (Sympatric speciation) occurs when the population is in the same environment/population/habitat; [1 mark]
- Mutations in the DNA can result in alleles whose phenotype results in different egg-laying preferences; [1 mark]
- (Resulting in) reproductive isolation **OR** no gene flow **OR** gene pools remain separate; [1 mark]
- (Leading to) different alleles selected **OR** changes in allele frequency; [1 mark]
- (Over time the maggots from different groups) cannot interbreed and produce fertile offspring; [1 mark]

[Total: 4 marks]

There isn't a physical barrier separating the species of maggot flies, they simply have different preferences on where to lay their eggs, sufficiently creating a separate gene pool, as members who consistently lay their eggs on the hawthorn fruit will generally be more likely to find mates in that same area. Over time, this can lead to accumulation of different mutations which are only passed on within the localised population and can lead to speciation as the question states.