IB · DP · Biology

2 hours 15 questions

Structured Questions: Paper 2

5.1 Evolution & Natural Selection

Easy (5 questions)	/32
Medium (5 questions)	/46
Hard (5 questions)	/40
Total Marks	**/118**

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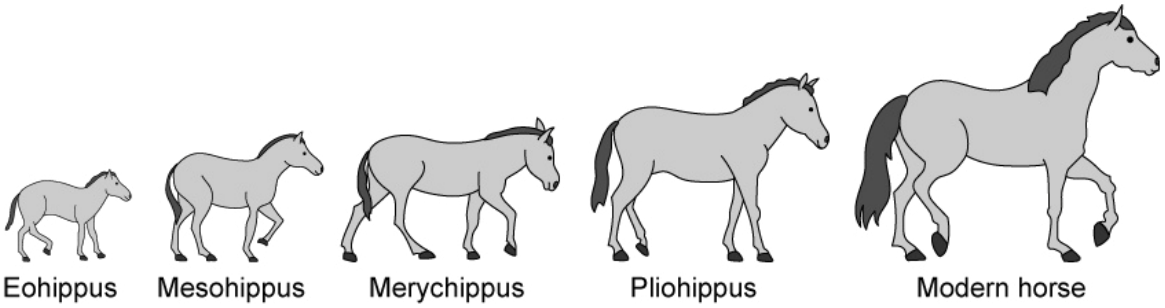
Easy Questions

1 (a) The diagram below shows the evolution of the modern horse (*Equus caballus*).



Define the term 'evolution'.

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(1 mark)

(b) State the name of the mechanism which drives evolution.

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(1 mark)

(c) There are several sources that provide evidence for evolution, such as selective breeding.

List **three** other sources of evidence for evolution.

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(3 marks)

(d) State **two** visible differences between *Eohippus* and modern horses.

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(2 marks)

2 (a) Two populations of cluster pine trees (*Pinus pinaster*) grew on opposite sides of a large mountain range. After many generations, scientists attempted to cross breed individuals from the two populations with each other but could not succeed. The scientists concluded that speciation occurred between the two populations.

Define the term 'speciation'.

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(1 mark)

(b) State **two** reasons why speciation occurred between the two populations of pine trees.

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(2 marks)

(c) Islands will very often contain many species that are endemic to those regions.

Describe a possible reason for this occurrence.

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(2 marks)

3 (a) The blackworm (*Lumbriculus variegatus*) is a species of worm native to North America and Europe. Their habitat includes marshes, swamps and ponds and they are a popular food source for fish kept in aquariums. Blackworms have a very unique way of reproducing, the segments that make up its body are able to regenerate into a complete individual on its own. Sexual reproduction is very rare in these worms.

(i) State the main source of variation in a blackworm population.

[1]

(ii) List **two** other sources of variation in a population.

[2]

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(3 marks)

(b) The blackworm in the image above grew a second tail, presumably due to an injury sustained on the first one. Its ability to regenerate body parts can be considered a useful adaptation.

(i) Define the term 'adaptation'.

[1]

(ii) State the use of the regeneration abilities of the blackworm as an adaptation.

[1]

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(2 marks)

(c) It takes a very long time for blackworms to reach sexual maturity and they need to be of a large body size before they reach this stage of their development, which typically only occur in their natural habitat. Shorter blackworms will reproduce asexually by fragmentation which occurs at a much higher rate than sexual reproduction. In laboratory settings, the worms are often used in experiments and need to be replaced frequently.

State the effect it would have on the body size of a blackworm population taken from a natural habitat, if they were kept in laboratory settings for a period of time.

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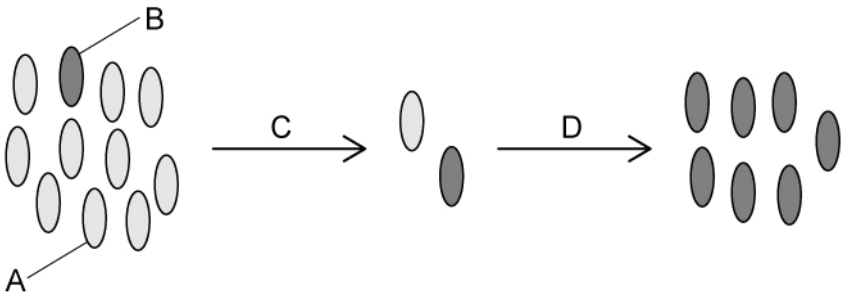
(1 mark)

4 (a) The following diagram illustrates the development of antibiotic resistance in bacteria due to a mutation that occurred in a non-resistant population.



Label the bacteria that are present at **A** and **B**.

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(2 marks)

(b) State the selection pressure that is applied at **C**.

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(1 mark)

(c) The mutation for antibiotic resistance is passed on to other bacteria at point **D**.

List **one** of the processes by which this could be done.

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(1 mark)

(d) State **one** strategy that could be used to reduce the rate at which resistance evolves in bacteria.

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(1 mark)

5 (a) *One mark is available for clarity of communication throughout this question.*

Selective breeding has played an important role in the domestication of wild plant and animal species.

State **three** examples of selective breeding in agriculture, along with the improved characteristics of each.

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(3 marks)

(b) Outline the process of selective breeding.

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(6 marks)

Medium Questions

1 (a) Researchers collected fish from a water source inside a cave and from the same water source in the open air.

They measured the diameter of the eyes of each fish as well as the length of its body. From these measurements they calculated the mean values for each site. Their results are shown in the table below.

	Fish in open air	**Fish in cave**
Mean diameter of eye / mm	0.23	0.10
Mean length of body / cm	8.49	5.82

An article published by a researcher several years before this study suggested that animals living in caves had similar adaptations; smaller eyes and a smaller body for decreased energy expenditure.

Evaluate this suggestion in the light of the data in the table above.

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(2 marks)

(b) The researcher decided to continue their investigation and calculate the genetic diversity of the fish. Their results are shown in the table below.

Gene	Allele	Percentage of fish with this allele	
		In the open air	In the cave
PGI	**P**	2.4	1.0
	Q	4.5	0.0
	R	61.8	95.7
	S	6.8	1.0
	T	19.7	0.0
ACO2	**A**	4.7	0.0
	B	100.0	21.3
	C	0.0	100.0

State, with a reason, what can be concluded about the genetic diversity of fish in the open air in comparison to fish in the cave.

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(2 marks)

(c) The percentage of fish with allele **C** in the open is different from the percentage of fish with allele **C** in the cave. Suggest a reason for this difference.

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(3 marks)

(d) Suggest how the researcher could find out if the fish living in the open are still the same species as those living in the cave.

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(1 mark)

2 (a) A group of biologists conducted an investigation on a remote archipelago (a collection of islands) in the Pacific Ocean. A species of mouse lives on these islands without any natural predators. The biologists measured the claw length of a large number of these mice.

On half of the islands, a species of snake was accidentally introduced that preys on the mice but that cannot climb trees. Several years after the snakes were introduced the biologists returned and found that on the islands with snakes, the claw length of the mice had changed. Some had shorter claws, enabling them to run faster, while others had longer claws, enabling them to climb trees.

Suggest the benefit to the scientists' investigation of there being islands without any snakes present.

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(2 marks)

(b) The evolution of long claws in the mice in part (a) was made possible by a mutation in the gene controlling claw length.

Explain how a mutation could lead to a change in claw length.

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(3 marks)

(c) When the biologists conducted the investigation in part (a), flooding of the islands was very rare. Now, due to climate change, flooding of the islands occurs more regularly. This flooding can regularly wipe out large numbers of ground-living species.

Using this information and the information from part (a), explain how the claw length of the mice on the islands are likely to be changing now.

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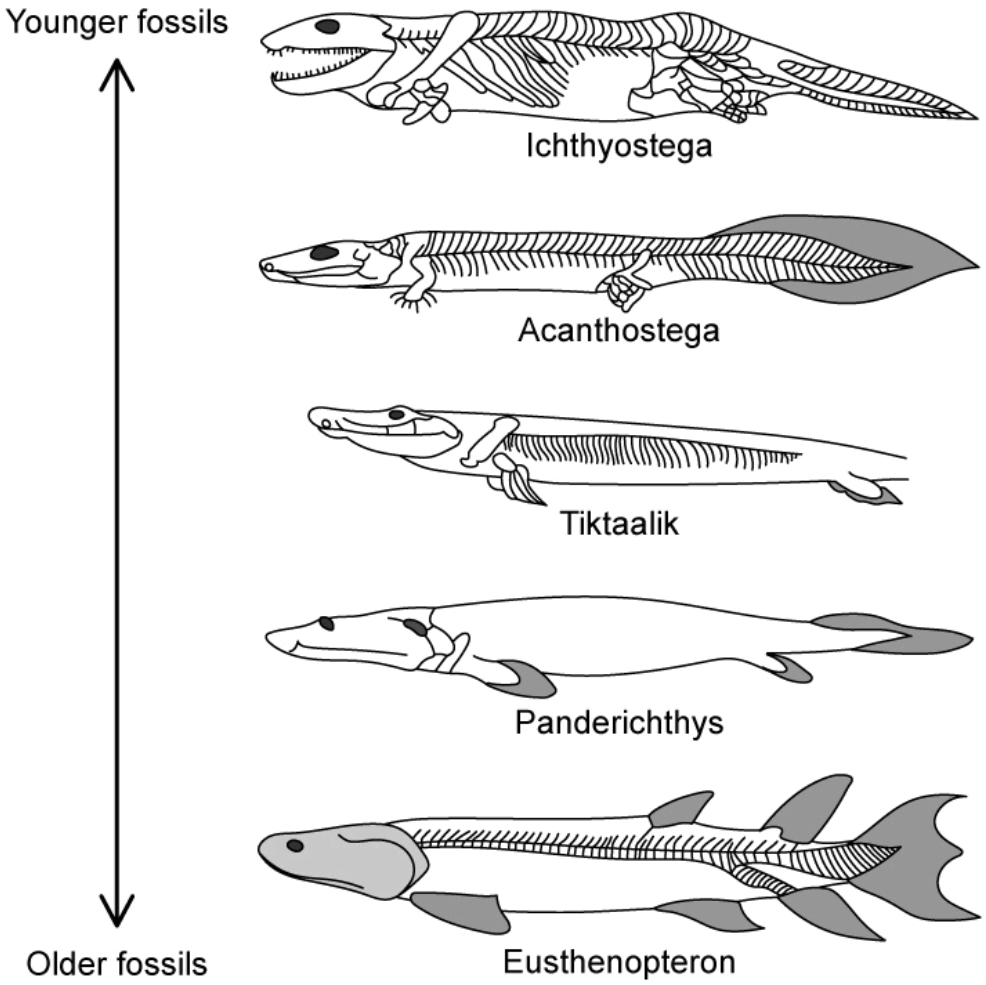
(3 marks)

3 (a) The image below shows a series of fossils in varying states of completeness. *Eusthenopteron* is an extinct genus of fish while *Ichthyostega* is an extinct genus of partially aquatic tetrapod (four-legged vertebrates).



Compare and contrast the fossil *Ichthyostega* with *Acanthostega*.

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(3 marks)

(b) Outline how this set of fossils provides evidence for the process of evolution.

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(2 marks)

(c) Suggest one limitation of fossil evidence for evolution visible in the image in part (a).

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(1 mark)

(d) The limbs of *Ichthyostega* and of modern tetrapods, taken together with the fins of marine mammals and the wings of birds are also considered to provide evidence for evolution.

Explain how these structures provide evidence for evolution.

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(2 marks)

4 (a) The Pyrenean desman (*Galemys pyrenaicus*) is a small, semi-aquatic, globally threatened mammal related to moles and shrews. It lives in the Pyrenees, a mountain range between France and Spain, and can be seen in the image below.

Suggest two adaptive features of the Pyrenean desman.

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(2 marks)

(b) The scientists found that there were two populations of desman living in the Pyrenees; a northern and southern population. Analysis showed that there was variation between the two populations. Some of the variation could be accounted for by environmental factors such as food availability, but some could not.

Outline a source of variation **other** than environmental factors.

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(2 marks)

(c) During a study that lasted many years, scientists found that the number of desman travelling from the northern population to the southern side of the mountain range was extremely low. The scientists suspect that the original desman species may have split into two different species.

Explain how the original desman species may have split into two separate species.

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(3 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Explain the importance of heritable variation in evolution.

(3 marks)

(b) Outline the equivalent features of selective breeding and evolution by natural selection.

(5 marks)

(c) Explain how natural selection can account for the development of antibiotic resistant bacterial strains.

(7 marks)

Hard Questions

1 (a) The apple maggot fly (*Rhagoletis pomonella*) is a species of fruit fly that lay their eggs on apples. As a result of this, they are often found in apple orchards where they can cause much damage to apple yields. Scientists studied two populations of apple maggot flies from orchards that were separated by a busy highway. They found that flies from the two populations had difficulty breeding successfully when kept in close confinement.

Suggest a reason for this observation.

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(3 marks)

(b) The size of one of the orchards that were studied by the scientists had systematically been reduced by the farmer to make way for grazing cattle. The table below shows the size of the apple orchard and the estimated population of apple maggot flies over time.

Year	Orchard size / m^2	Estimated number of apple maggot flies
1995	424	45 000
2000	316	36 000
2005	157	18 000
2010	132	12 000
2015	78	7 000

Calculate the percentage change in the population of apple maggot flies from 1995 to 2015. Show your working.

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(2 marks)

(c) The scientists estimated the apple maggot fly population size recorded in the previous table by sampling four trees from five randomly selected areas of the orchard between May and July. They concluded that the reduction in orchard size caused a significant decrease in apple maggot flies between 1995 and 2015.

Using the data from part b) and your own knowledge, evaluate the scientist's conclusion.

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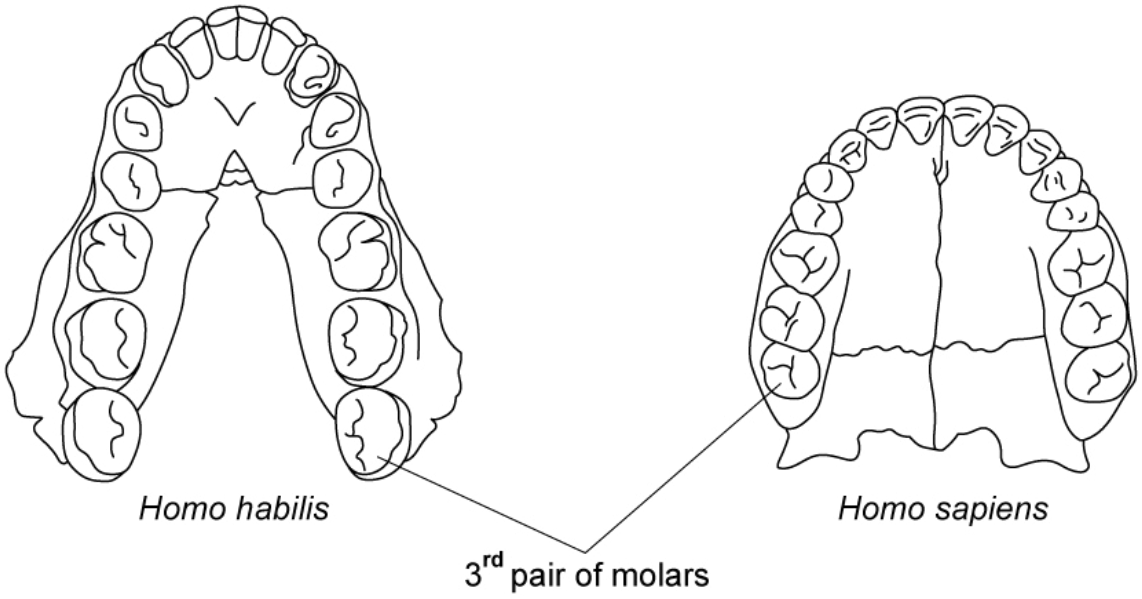
(3 marks)

2 (a) Wisdom teeth are considered to be an example of vestigial structures in modern humans (*Homo sapiens*), since they serve very little purpose. They are third molars that human ancestors (such as *Homo habilis*) used to grind down large amounts of raw plant material. These early humans had larger jaws that could accommodate a third pair of molars but in modern humans, they may cause complications that require them to be surgically removed.

The diagram below compares the lower jaw of *Homo habilis* and *Homo sapiens* according to scale.



Based on the information above, suggest a reason why wisdom teeth became vestigial structures in *Homo sapiens*.

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(2 marks)

(b) Explain why humans still have wisdom teeth, even though it serves no purpose for them.

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(1 mark)

(c) Wisdom teeth can cause a range of oral health problems in certain people, including gum infections, damage to other teeth and problems with eating due to teeth being pushed out of position by the presence of wisdom teeth. Some scientists believe that this may affect their persistence in future generations.

(i) Predict the possible fate of wisdom teeth in future human populations, based on this information and your knowledge of natural selection.

[1]

(ii) Explain your answer at part i).

[1]

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(2 marks)

(d) Compare and contrast vestigial structures with homologous structures.

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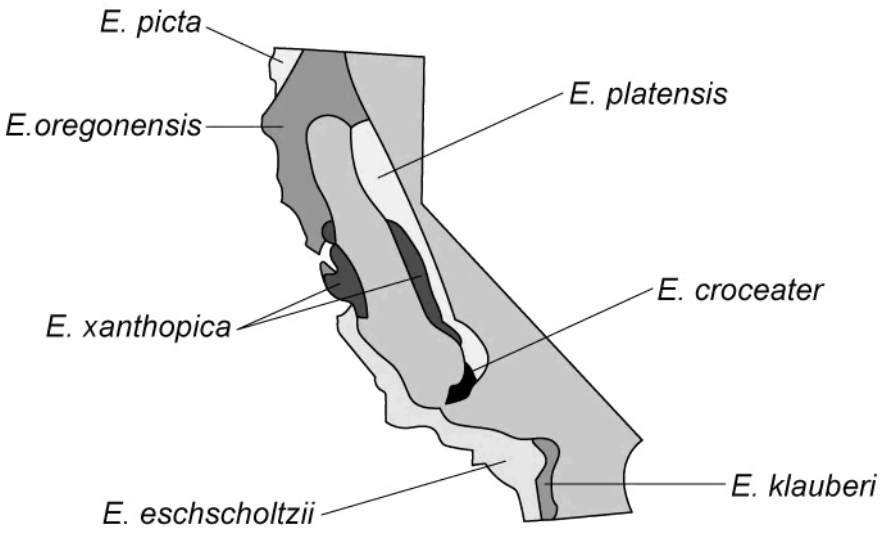
(2 marks)

3 (a) *Ensatina* is the genus name for a group of lungless salamanders (a type of amphibian) that occur in certain regions of the USA. Seven subspecies have been identified that are spread across California, each of which shows slight differences in colouration. Some scientists argue that the *Ensatina* populations represents different species and that they are not simply a continuum of a single species. This is due to the fact that some of the populations are not able to successfully breed with one another anymore.

The map below shows the distribution of the subspecies of *Ensatina* salamanders across California.



Explain the process that could have resulted in the slight variations in colouration between different *Ensatina* subspecies.

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(3 marks)

(b) Some of the more closely located populations of *Ensatina* can successfully breed with one another but the western population of *E. eschscholtzii* cannot interbreed with the eastern population of *E. klauberi*.

Based on the information provided, evaluate the claim made by some scientists that the different subspecies of *Ensatina* should be classified as separate species.

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(2 marks)

(c) Fossils of *Ensatina* salamanders have been found at several sites across the USA and indicates that they have been around for millions of years. The fossilised vertebrae showed great similarities in structure to modern-day *Ensatina* species, except they were slightly smaller.

Based on the information provided, explain the importance of these fossils as evidence for evolution.

(2 marks)

4 (a) The turtle-headed sea snake (*Emydocephalus annulatus*) can be found in waters off the coast of Australia, New Zealand and New Caledonia. These snakes usually display a colouration of banded patterns of white with dark rings, although some individuals exhibit a single dark colour with no banded patterns. The dark parts of the skin contains a high concentration of the pigment melanin, which binds to certain trace elements present in the water. These trace elements are removed from the body when the snake sloughs off the skin. It was found that melanic sea snakes will slough off the skin more frequently than those with banded colouration.

Scientists studied the frequency of melanic sea snakes from several sites in waters surrounding urban-industrial areas and waters from non urban-industrial areas. The results are shown in the table below.

Site	Melanic sea snakes in urban-industrial waters / %	Melanic sea snakes in non urban-industrial waters / %
A	78	23
B	95	0
C	64	14
D	92	2
E	98	7

Calculate the percentage difference in the mean frequency of melanic snakes found in urban-industrial waters and those that were present in non urban-industrial waters. Show your working.

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(3 marks)

(b) Suggest a possible explanation for the data provided in part a).

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(2 marks)

(c) Based on the information provided in part a), deduce the adaptive advantage of melanism to turtle-headed sea snakes.

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(3 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Natural selection would not be possible without the presence of variation within a species.

Explain how variation provides a way for natural selection to occur.

(3 marks)

(b) Mutation, meiosis and sexual reproduction are all considered to be sources of variation.

Outline the way in which each of these factors contributes to variation within a species.

(7 marks)