1. Patients in hospital can be at risk from infections such as MRSA. The bacteria that cause MRSA are resistant to a variety of antibiotics.

New antibiotics need to be developed as a result of infections such as MRSA.

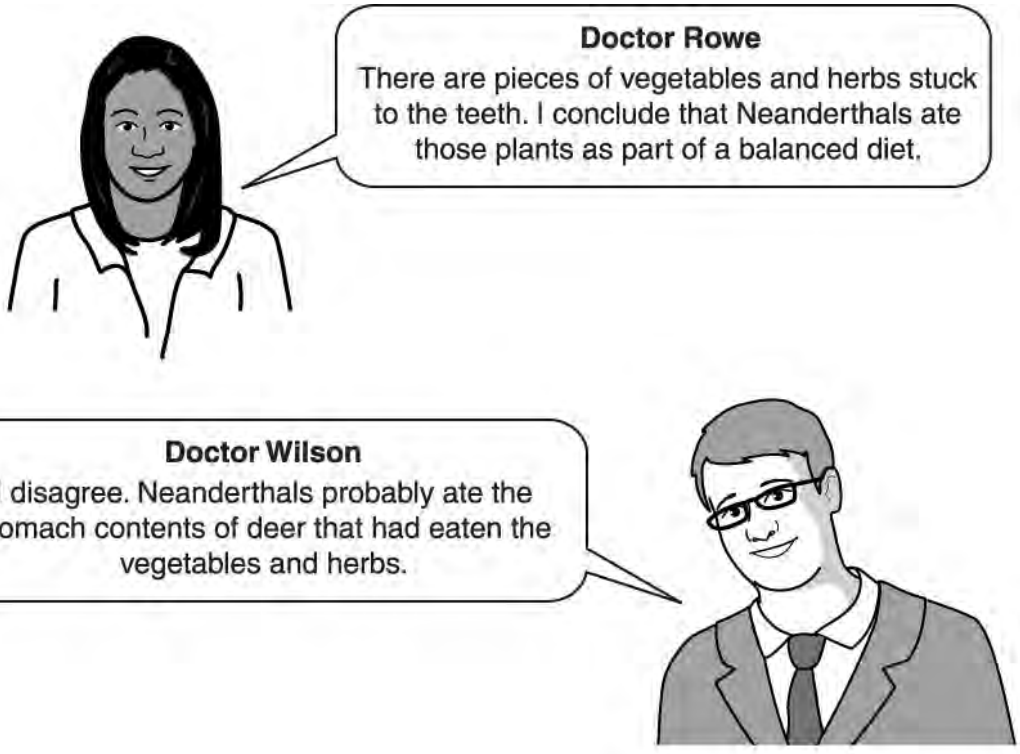
Use the theory of natural selection to describe how antibiotic resistance in bacteria is increasing.

[5]

2(a). Neanderthals are an extinct species of humans.

Fossils of Neanderthals help us investigate the evolution of humans.

Two scientists talk about fossils of Neanderthal teeth.



Both scientists looked at the same data.

Suggest **two** reasons why they developed different explanations.

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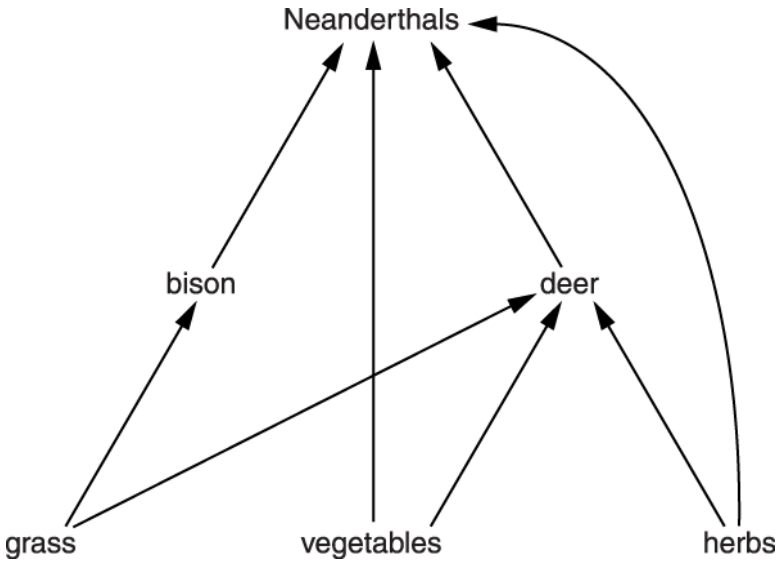
[2]

(b). The diagram shows part of the Neanderthals' food web.



Use the food web to explain why the sizes of the bison population and the deer population are interdependent.

---

[3]

(c). Neanderthals and modern humans are different species.

Scientists think both species evolved from a common ancestor called Heidelberg Man.

Choose words from the list to complete the explanation of how two different species evolved from Heidelberg Man.

Each word may be used once, more than once or not at all.

competition **isolation** **mutation** **selection** **variation**

The Heidelberg Man population split into two groups. The two groups lived in _____.

There was genetic _____ in both groups, caused by _____ of individuals' genes.

This gave the individuals in each group different characteristics.

Each group became adapted to its own environment because of the natural _____ of individuals with beneficial characteristics.

[3]

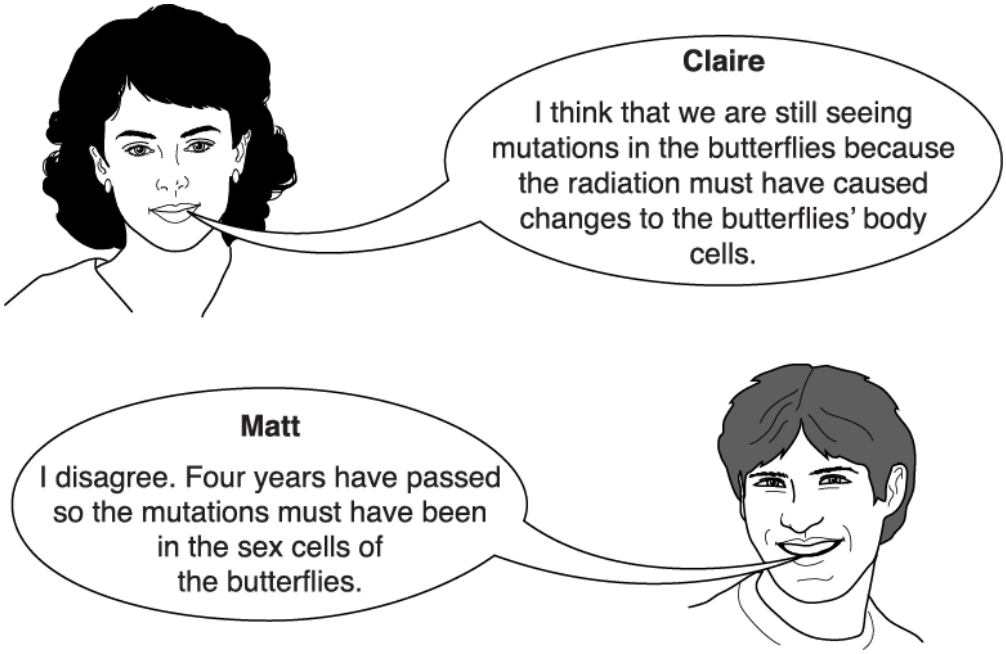
3(a). In 2011, a huge earthquake in Japan caused a radiation leak from a nuclear power station.

Two months later, butterflies were collected from different areas near the power station.

Some of the butterflies had much smaller wings than normal butterflies, and irregular shaped eyes.

Some scientists believe that the radiation caused a random change in the genes of butterflies.

Claire and Matt are discussing the possible mutations in the butterflies four years after the radiation leak.



Who do you agree with?

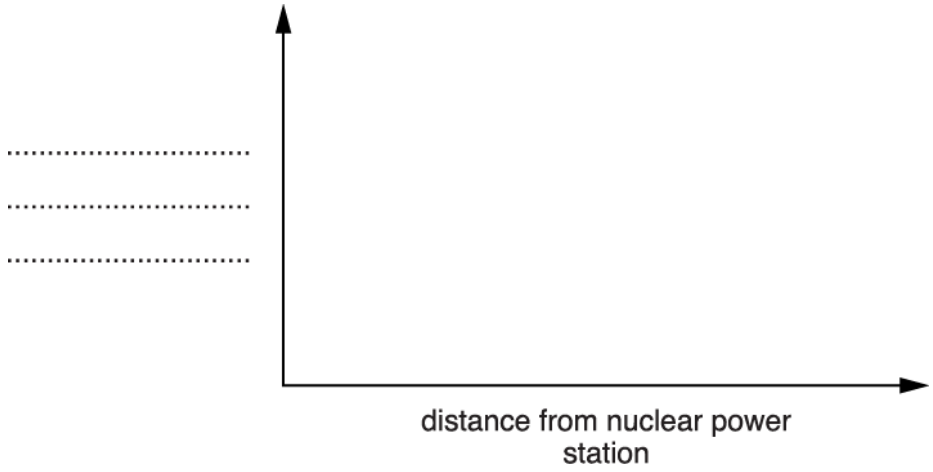
Give a reason for your answer.

---

[1]

(b). Butterflies collected closer to the power station had more genetic changes than those collected further away.

Scientists start to draw a graph to show their results.



(i) On the graph:

- complete the axis label
- draw a line to show the relationship between the distance from the nuclear power station and the number of genetic changes.

[2]

(ii) The graph does not prove that the radiation leak from the nuclear power station caused the mutations in the butterflies.

Suggest what evidence scientists would need to be more certain of the cause.

---

[2]

4. There is a huge variation of life on Earth.

The processes of natural selection and selective breeding have been involved in producing this variation.

Compare natural selection and selective breeding.

Include the similarities and differences between the two processes.

The quality of written communication will be assessed in your answer.

[6]

5. The process of evolution has produced many new species.

Explain how evolution produces new species.

The quality of written communication will be assessed in your answer.

[6]

6. Plants can be infected by diseases caused by pathogens.

The plant disease ash dieback was first recorded in the early 1990s in Poland.

Since then, many thousands of trees in northern Europe have become infected.

Ash dieback was first found in eastern parts of Great Britain (GB) in 2012, and has been spreading across the country ever since.

The British outbreak of ash dieback started in woodland in Norfolk.

Much of the woodland has died, but one ash tree has shown tolerance to the disease. This tree was named 'Betty' by scientists. Tolerant trees have also been found in mainland Europe.

(i) Explain how scientists could use selective breeding to produce ash trees with improved tolerance.

---

[3]

(ii) New woodland could be planted using cuttings from Betty.

Explain why this could be a **disadvantage** during a future outbreak of plant disease.

[2]

(iii) Explain how gene technology could be used to produce ash trees with improved tolerance.

[4]

7. The female mosquito *Aedes aegypti* is responsible for the transmission of diseases such as Zika virus.

In May 2015, Zika virus was reported in Brazil and began to spread rapidly.

The mosquito feeds mainly on human blood. The virus is spread when a female *Aedes aegypti* mosquito bites an infected human and then bites an uninfected human.

(i) The mosquito responsible for the spread of Zika has become resistant to some of the insecticides used to kill it.

Explain how a population of mosquitos could have become resistant to an insecticide.

---

[3]

(ii) One way scientists tried to solve the problem was to make genetically engineered mosquitoes that had a 'kill switch' gene. This gene caused the mosquitoes' offspring to die.

Describe the steps a scientist would use when genetically engineering a mosquito to have the 'kill switch' gene.

---

[3]

(iii) The ‘kill switch’ gene codes for the production of a protein called tTAV.

The tTAV protein blocks the transcription of other genes essential for mosquito survival.

When breeding the mosquitos in the laboratory a chemical called tetracycline is used.
Tetracycline binds to the tTAV protein and deactivates it.

Suggest why scientists use tetracycline when breeding the genetically engineered mosquitos.

---

[1]

(iv) Scientists thought using genetically engineered mosquitos was a better solution than using insecticide.

Do you agree?

Explain your reasons.

---

[3]

8. The Galapagos Islands are a group of 13 islands found in the Pacific Ocean.

Charles Darwin visited the Galapagos Islands during the 19th century.

He collected samples and made observations.

This work helped Darwin to develop a new explanation for the evolution of species.

(i) Which of the following are observations made by Darwin?

Tick (✓) **two** boxes.

There are differences between fossils and living examples of similar organisms. ☐

Pea plants with red flowers can produce offspring with white flowers. ☐

There is usually extensive variation within a population of a species. ☐

Some bacteria have become resistant to antibiotics. ☐

Isolated populations of the same species living in different places have different characteristics. ☐

[2]

(ii) Darwin suggested a theory to explain his observations.

Write down the name of the theory he suggested.

---

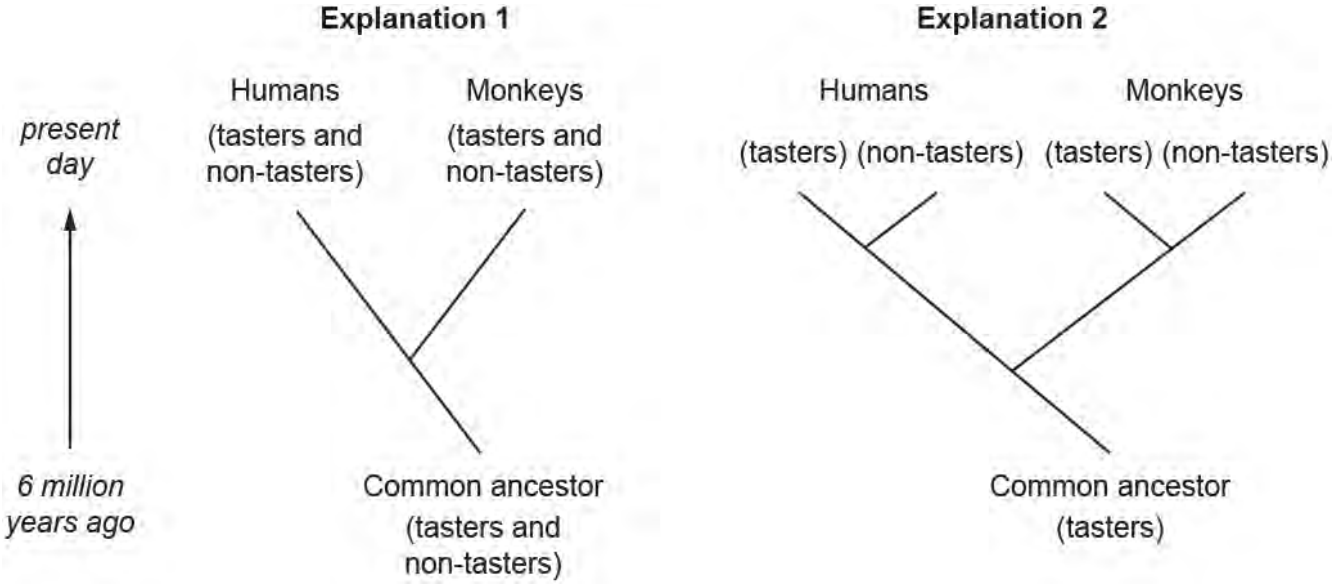
[1]

9. Amaya reads an article in a magazine which explains that genes code for the production of a taste receptor on the tongue.

Taste receptors are proteins.

Monkeys also have different variants of the gene that affects how they taste bitterness.

Scientists have proposed two explanations for how the non-tasting variants could have evolved in humans and monkeys.



Scientists have discovered that the non-tasting variants in humans and monkeys have different DNA sequences, even though they have the same effect.

Which explanation of how they evolved is most likely to be correct?

Explain your answer.

---

[2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			Any five from Bacteria with resistance gene have an advantage ✓ Resistance occurs due to a mutation ✓ They will not be killed by antibiotics / are more likely to survive ✓ They will reproduce ✓ And pass on this gene to future generations ✓ So the population becomes more antibiotic resistant ✓	5	
			Total	5	
2	a		any 2 from: they interpreted the data in different ways; not enough data / not enough evidence; explanations are not obvious from data / the scientists used creative thinking; their (different) backgrounds / experience / interests / prior knowledge / opinions influenced their judgment	2	Ignore "they developed different explanations" as this is in the stem of the question. do not credit 'looked at different data' Examiner's Comments This question was difficult as candidates has to give 2 reasons why scientists developed different explanations from looking at the same evidence.

Question			Answer/Indicative content	Marks	Guidance
	b		**Max 3 from**: idea that the size of the deer population depends upon (or is affected by) the size of the bison population / ORA (1) <u>competing / competition</u> for the same resources(e.g. food) (1) relevant example (2)	3	**accept** idea that if the size of the deer / bison population increases the other will decrease / ORA **do not credit** "eat / have the same food" without reference to competition *e.g:* if Neanderthals eat more bison, they will eat fewer deer, so deer population increases *(2 marks)* *e.g.:* if deer population increases, there will be less grass for the bison, so bison population decreases *(2 marks)* **Examiner's Comments** Candidates who could explain, within the context of the question, a meaning of the term interdependence and use the available food web to give examples scored the highest marks.
	c		isolation; variation; mutation; selection	3	four correct = 3 marks three correct = 2 marks two correct = 1 mark one correct = 0 marks **Examiner's Comments** The majority of candidates could identify the correct responses to complete the evolution sentences.
			Total	**8**	
3	a		*Matt because:* new characteristics will only be seen if they are passed down to the offspring (via sex cells) OR *Claire because:* there could still be background radiation causing mutation effects in the butterflies	1	<u>Examiner's Comments</u> The best responses recognised the Matt's idea was linked to mutated genes being passed on. Few candidates linked Claire's answer to background radiation.

Question			Answer/Indicative content	Marks	Guidance
	b	i	label: (number / amount / butterflies) genetic changes / mutations any line that starts higher on the left and ends lower on the right	2	do not allow horizontal or vertical lines Examiner's Comments Most candidates could label the axis correctly and draw a line to describe the relationship between number of mutations and distance from the nuclear power station.
		ii	a (causal) mechanism (1) **example** of more evidence (1)	2	**Ignore** 'do more research' unless qualified e.g. take a larger sample size, weather conditions at the time, use secondary data, find / observe changes to DNA Examiner's Comments The majority of the candidates found it challenging to identify the causal mechanism and give an example of further evidence required.
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
4			**[Level 3]** Answer includes similarities AND differences between natural selection and selective breeding. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **[Level 2]** Answer includes one similarity AND / OR one difference. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **[Level 1]** Answer includes a feature of EITHER natural selection OR selective breeding. Quality of written communication impedes communication of the science at this level. (1 – 2 marks) **[Level 0]** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to C** **Indicative scientific points may include:** **similarities**: • they are both ways of breeding animals / plants • both produce changes in characteristics • both rely on variation in individuals • resulting from mutation / DNA changes • both select the most favourable characteristics • these characteristics are passed onto offspring • over time more individuals possess the characteristics **differences**: • NS occurs naturally and SB is controlled by humans • NS takes longer than SB ora • NS selects traits that are useful to survival and SB selects traits that are useful to humans • allow credit for examples to illustrate the differences Examiner's Comments This question differentiated well. Good responses were able to provide a number of similarities and differences between natural selection and selective breeding.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
5			**Level 3 (5–6 marks)** Gives a description of evolution AND speciation using key terms. Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Gives a description of evolution OR speciation using key terms. Quality of written communication partially impedes communication of the science at this level. **Level 1 (1–2 marks)** Makes a simple statement about evolution OR speciation Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	**This question is targeted at grades up to C** **Indicative scientific points on Evolution may include** • Natural selection • variation • mutation • competition • selective survival / survival of best adapted / survival of fittest • reproduction • pass on characteristic / genes **Indicative scientific points on Speciation may include** • population gets **split** into two groups (eg new mountain range or new river etc) • reproductive isolation • different / changed environments • **split** populations become different • different species can not interbreed (eg due to mating seasons / courtship / genetic incompatibility) **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** This was the third of the six-mark extended-writing questions. There were some excellent answers but the process of speciation was not well known or well explained. Most candidates gained marks for an explanation of natural selection, at the lowest level showing knowledge of adaptation and mutation but few gave a coherent full description of natural selection and how it drives evolution.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
6		i	cross Betty with other tolerant/resistance trees / breed two tolerant or resistant trees ✓ test/identify the offspring for tolerance/resistance to ash dieback ✓ select/breed the (most) tolerant/resistance offspring (and repeat) ✓	3 (AO 2.1 × 3)	<u>Examiner's Comments</u> In the slightly unfamiliar scenario of plants rather than the animals, candidates did not explain the process of selective breeding and gave responses involving taking cuttings, cloning or genetic engineering. The key words 'selective breeding' appear to have been ignored.
		ii	the cuttings will be genetically identical to Betty / will have no genetic variation ✓ could all have (a variant/allele that codes for) susceptibility to a different disease/pathogen ✓	2 (AO 2.1) (AO 1.1)	ALLOW will be clones of Betty but DO NOT ALLOW will be similar to Betty /have the same genes as Betty <u>Examiner's Comments</u> Many candidates were able to recognise the fact that clones were genetically identical and a number then went on to explain that they would be susceptible to another disease (rather than the same one). Additionally there was some confusion between resistance of the tree and of the pathogen. A common misconception was the use of the term immunity in relation to the tree.

Question			Answer/Indicative content	Marks	Guidance
		iii	sequence the genomes of Betty / other tolerant trees ✓ look for variants/alleles/sequences they have in common ✓ isolate/replicate variants/alleles/sequences associated with tolerance/resistance ✓ use genetic engineering to introduce tolerance/resistance (variants/alleles/sequences) into new ash trees ✓	4 (AO 2.1 × 4)	ALLOW use of (restriction) enzymes for this process ALLOW description of a method of genetic engineering <u>Examiner's Comments</u> This longer response question was designed to assess candidates' knowledge of the whole process of genetic engineering, set in a slightly different scenario. Higher ability candidates produced responses which included sequencing of genomes and the use of genetic engineering.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
7		i	Any three from: (random) mutation in DNA/gene which creates a new genetic variant ✓ resistant mosquitos survive ✓ the resistant mosquito reproduces and passes on the resistant variant ✓ so the resistant variant becomes more common in subsequent generations of mosquitoes ✓	3 (AO 2.1 x 3)	ALLOW different version/mutated/resistance gene/allele for genetic variant throughout. Examiner's Comments This question required candidates to be very precise when using terminology. Whilst many certainly had the right idea as to how the population would become resistant, they struggled to communicate this effectively. Many lost marks here for stating the mutation would be passed on, rather than stating the genetic variant that arose as a result of the mutation. This is certainly an area where centres could improve candidate use of terminology for future examinations.
		ii	Any three from: isolate the gene ✓ replicate/copy the gene ✓ use of a vector/plasmid ✓ to insert the gene into (mosquito) cells ✓ select the modified cells ✓	3 (AO 1.1 x 3)	ALLOW (enzymes to) cut out the gene ALLOW virus as an example of a vector Examiner's Comments This question wanted candidates to state the main stages of the process of genetic engineering, but the context of the question elevated the demand and thus it presented as a challenging question. Those that did well on this question often scored the marks for isolating, removing and replicating the gene. Inserting the gene into the 'cells' of the mosquito was seen only on occasion. Centres should be encouraged to discuss examples of genetic engineering in a variety of species as this will help prepare candidates for this type of question.

Question			Answer/Indicative content	Marks	Guidance
		iii	Any one from: essential genes are transcribed so mosquitos can survive and reproduce in lab✓ only kills offspring not the original (breeding) mosquito✓	1 (AO 2.1)	Examiner's Comments This was an abstract question requiring good skills of deduction and linking of ideas to work out why scientists would use the tetracycline when breeding genetically engineered mosquitos. Many did not appear to understand the role of the Tetracycline, were perhaps unfamiliar with the term transcription, or were unable to make the link to the need for those mosquitos used in the breeding process to survive.

Question			Answer/Indicative content	Marks	Guidance
		iv	**Any three from:** *yes because:* **Max. two from:** insecticides can bioaccumulate in the food chain ✓ insecticides can be toxic to other insects ✓ idea of killing other insects would affect the food chain ✓ **Max. one from:** idea that pollinators could be killed ✓ insecticides could be washed/run off into other communities/ecosystems ✓ genetic engineering should not affect other organisms ✓ insecticides are less effective due to resistance✓ new insecticides will need to be developed and this may be costly ✓ *no because:* **Max. two from:** long term studies would be needed to check for adverse effects AW✓ there are moral concerns about modifying genomes AW✓ **Max. one from:** inserted genes could spread to other organisms ✓ costly to genetically engineer/insecticides may be less expensive ✓ may need to keep breeding/releasing genetically engineered mosquitos ✓	3 (AO 2 x 1.1) (AO 2.1) (AO 2 x 1.1) (AO 2.1)	no marks for saying yes/no; the marks are for the explanation <u>Examiner's Comments</u> This question wanted candidates to consider the advantages and disadvantages of both genetic engineering and the use of insecticides. Most candidates agreed that genetic engineering was the better solution but very few candidates were able to explain why they thought this. Many began on the right lines, indicating that the insecticide would not be as effective due to resistance but did not take this forward to consider the wider impact that insecticides could have, such as affecting other species, or potential bioaccumulation. Those candidates that performed better on this question often did so for considering the benefits and drawbacks of using genetically engineered mosquitos.
			Total	10	

Question			Answer/Indicative content	Marks	Guidance
8		i	There are differences between fossils and living examples of similar organisms✓ Isolated populations of the same species living in different places have different characteristics ✓	2 (AO 1.1 x 2)	
		ii	natural selection ✓	2 (AO 1.1)	ALLOW survival of the fittest Examiner's Comments Question (a) (i) and (a) (ii) tested candidate knowledge of the work carried out by Darwin in the development of his theory of evolution by natural selection. A common error in (a) (i) was the selection of the statement 'There is usually extensive variation within a population of a species'. In (a) (ii) candidates often only used the stem of the question to state the theory was evolution, rather than natural selection.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
9			Any two from: *Explanation 2 because:* links different DNA sequences/variants to being separate mutations / the mutations did not occur in the common ancestor idea that if explanation 1 was correct, the mutation would have occurred in the common ancestor and the DNA sequences would be the same ✓ states mutations would occurred after speciation/after they became separate species AW ✓ despite the low chance of two mutations creating the same outcome ✓ OR *cannot tell / insufficient evidence to decide / both could be correct /or explanation 1 could be correct because:* it is not clear how different the DNA sequences are so difficult to tell ✓ the non-tasting variants could have mutated further✓ after they appeared in the common ancestor/after speciation (as in Explanation 1) ✓ it is not clear how different the DNA sequences are so difficult to tell ✓	2 (AO 3.1a) (AO 3.2a) (AO 3.1a) (AO 3.2a)	No marks for 'explanation 2' unqualified No marks for 'cannot tell / insufficient evidence to decide / both could be correct' unqualified <u>Examiner's Comments</u> This was a very challenging question which required candidates to analyse a diagram and use some information to determine which explanation of the evolution of non-tasting variants was most likely to be correct. Those that did score on this question generally opted for explanation 2 as the most likely explanation, realising that either there were two separate mutations which gave rise to different DNA sequences or that the mutation must have occurred after speciation. Although few candidates gained credit for this question, it was good to see that the majority of candidates had the confidence to have a go at this very demanding question and in many cases came close to gaining a mark.
			Total	2	