1. Fill in the gaps in the paragraph below with the best term from the list.

resistant	genes	selective breeding	immune
natural selection	chromosomes	offspring	

A wheat breeder notices that some of his wheat plants do not die when attacked by a fungus.

These plants are _____ to the fungus. He uses these plants to breed from and selects from their _____ to breed the next generation. This is an example of _____.

[3]

2(a). Lamarck, Darwin and Wallace were three scientists responsible for our understanding of evolution.

Jean Baptiste Lamarck

Charles Darwin

Alfred Russel Wallace

In the early 1800s, most scientists such as Lamarck thought that when organisms acquired a characteristic during their life time, they could pass this characteristic on to their offspring. He thought that the giraffe had a long neck because it stretched to reach leaves from the branches of trees. He thought that giraffes that stretched their necks the most would then pass on this characteristic to their offspring.

Darwin and Wallace did not believe this theory. They spent many years collecting different species of animals and plants from all over the world and they both came to the same conclusion.

Darwin and Wallace thought that life evolved due to a process of natural selection. Both Darwin and Wallace realised that if this process was repeated over many generations, it could lead to the wide variety of different species that we see around us today.

Today most scientists around the world believe Darwin's and Wallace's theory to be correct.

(i) Evaluate Lamarck's theory and suggest why most scientists now believe Darwin and Wallace's theory of evolution.

---

[4]

(ii) Wallace sent Darwin his ideas to check that he had not made any mistakes.

Put a tick (✓) in the box next to the statement that best describes this process.

Repeatability	
Controlling variables	
Extrapolation	
Peer review	

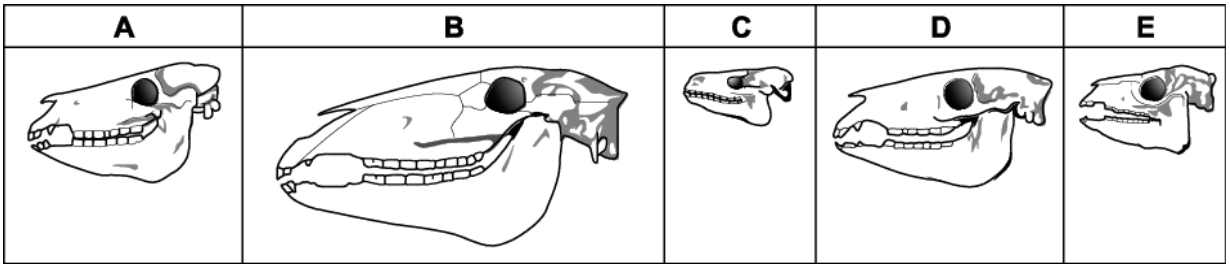
[1]

(b). Scientists use fossils to provide evidence for evolution.

The five drawings below are of fossil skulls of horses.

The drawings, **A**, **B**, **C**, **D** and **E** can be used to show how horses have evolved.

The drawings are in the wrong order.



Complete the boxes to show how the horses have evolved.

The first and last have been done for you.

C				**B**

[2]

(c). Describe how the fossils can be used to provide evidence for the evolution of horses.

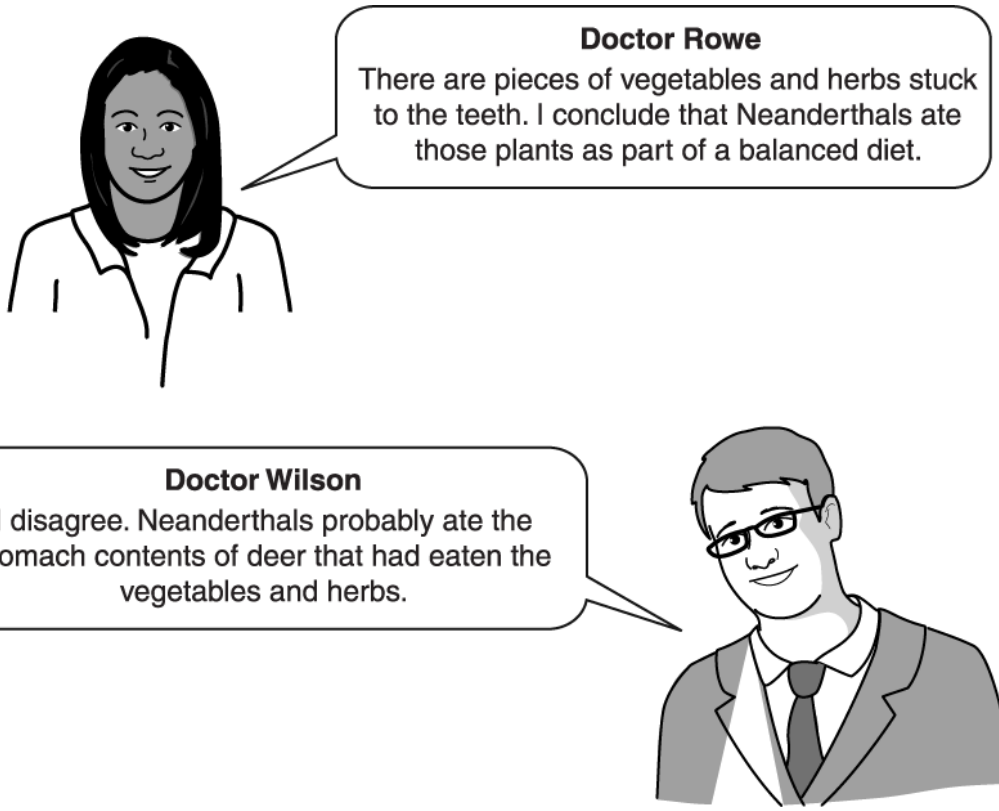
Use ideas of similarities and differences between the drawings and your own knowledge in your answer.

[4]

3. 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.



Complete the table.

Put **one** tick (✓) in each row to answer the questions.

	Only Doctor Rowe	Only Doctor Wilson	Both scientists	Neither scientist
Who describes data?				
Who suggests an explanation for the data?				
Who has used creative thinking to develop an explanation?				

[3]

4. Neanderthals and modern humans are different species.

Both species evolved from the same ancestor.

Statements **A** to **E** show steps in the process of evolution.

The statements are in the wrong order.

A The groups lived in isolation in different conditions.
B Some individuals were better able to survive to reproduce.
C The ancestor population split into two groups.
D The groups evolved to become two different species.
E Mutations caused genetic variation in each group.

Write the letters in the boxes to show the correct order.

One has been done for you.

[3]

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

Two months later, butterflies were collected in a number of 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 the butterflies.

What name is given to a random change in a gene?

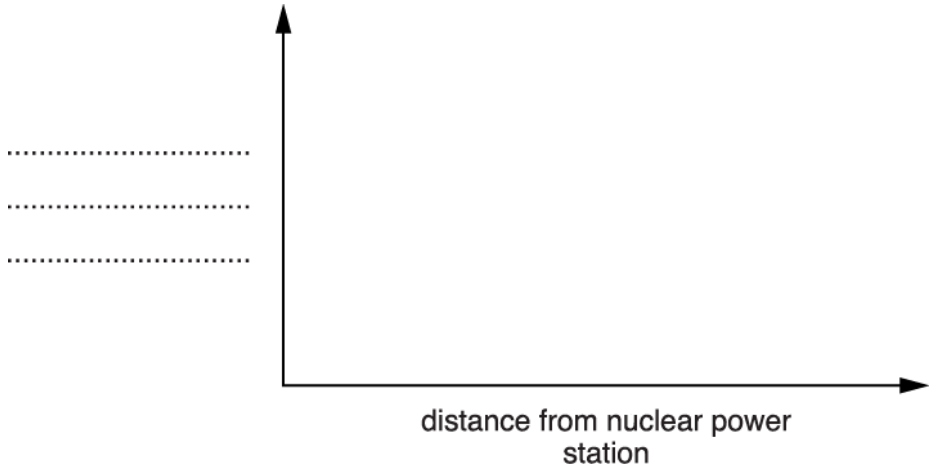
Put a ring around the correct answer.

evolution isolation mutation variation

[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) Scientists cannot be certain that radiation is causing the genetic changes in the butterflies.

Suggest why.

---

[2]

(c). Genetic changes can contribute to the process of natural selection.

Explain how.

[3]

6. 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]

7(a). 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]

(b). A team of scientists are looking for new species in the Amazon jungle.

They discover an unusual beetle.

Explain what would prove that it was a new species.

[2]

8(a). Bulldogs are an example of a breed of dog that has been selectively bred.

(i) Describe how dogs are selectively bred.

---

[2]

(ii) Explain the impact of selective breeding on domesticated animals such as dogs.

---

[1]

(b). A cockapoo is a dog that results from the mating of two different breeds of dog; a cocker spaniel and a poodle.

The cockapoo is not a new species.

Explain why.

---

[2]

9. 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 many 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]

10. Warfarin is a medicine that helps to prevent the formation of blood clots.

It is given to people who are at risk from a blood clot blocking one of their veins.

* Warfarin has also been used as rat poison since 1948.

However, many populations of rats are now resistant to warfarin.

Explain how a population of rats could have become resistant to warfarin.

---

[6]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			Resistant ✓ Offspring ✓ Selective breeding ✓	3	
			Total	3	
2	a	i	Any two from *Evaluating Lamarck's theory* 1. Idea that stretched neck is environmental ✓ 2. Environmental effects not inherited ✓ 3. Genes needed for inheritance ✓ Any two from *Reasons why evolution is now believed* 4. Mutation in genes now understood ✓ 5. Variation in offspring shown to be linked to DNA differences ✓ 6. Idea of mole evidence to support theory ✓	4	MP4 **ALLOW** idea of DNA better understood MP5 **ALLOW** an example MP6 **ALLOW** examples such as MRSA
		ii	Peer review ✓	1	
	b		E before A ✓ A before D ✓	2	
	c		Any four from 1. Fossils show how organisms have changed over time ✓ 2. Idea that size gets bigger over time ✓ 3. Idea that basic shape is the same ✓ 4. Similarity in shape indicates a common ancestor / specific example of similarity e.g. position / shape of jaw ✓	4	**ALLOW** a statement the older the fossil, the smaller it is – mark points 1 and 4
			Total	11	

Question			Answer/Indicative content	Marks	Guidance
3			<table><tr><th>Rowe</th><th>Wilson</th><th>Both</th><th>Neither</th></tr><tr><td>✓</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td>✓</td><td></td></tr><tr><td></td><td>✓</td><td></td><td></td></tr></table> (1) (1) (1)	3	**Examiner's Comments** It was clear from this question and the response observed that some candidates had a clear understanding of how to interpret data and as a result scored all three marks. Other candidates did not appear to understand how to analyse the information provided and as a result were unable to select the appropriate answers. A full range of marks was observed for this question, with the vast majority of candidates scoring one or more marks. Common errors included the selection of 'neither scientist' for the 'Who describes data' row of the table, which may be a result of students thinking that data had to be in the form of numbers. Centres should ensure candidates are aware that observational and numerical data both count as data. Concept cartoons provide a good method to analyse key features such as descriptions of data and explanations.
			Total	**3**	
4			C before E (1) E before B (1) B before D (1)	3	correct order: C **(A)** E B D **Examiner's Comments** Most candidates scored at least one mark for this question with a high proportion scoring two marks. Statements C and E were often in the correct order, however statements B and D were commonly given in the incorrect order.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
5	a		Mutation (1)	1	Examiner's Comments Just over two thirds of candidates correctly identified mutations as the correct name for a random change in a gene.
	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 In this question candidates were asked to use the information provided to complete the axis label on the graph and draw a line to show the relationship described. This question discriminated well; a full range of marks was observed. Candidates approached the graph in a variety of ways. The axis label sometimes had superfluous information in addition to the desired answer 'genetic changes'. Candidates should endeavour to be more concise in their axis labelling. Falling numbers of butterflies with mutations, as distance from the power station increase seemed difficult to translate into a downward sloping line. Those candidates gaining one mark predominately did so for the correct labelling of the axis.

Question			Answer/Indicative content	Marks	Guidance
		ii	*any two from*: suggestion of another cause / there might be another factor causing the changes (1) need more evidence / need more data (1) only shows a correlation (not enough to prove a cause) (1)	2	examples of other causes include environmental change / pollution / other gases / age / it happened naturally ignore evolution / natural selection / different species of butterfly as another cause **do not allow no** evidence <u>Examiner's Comments</u> This question asked candidates to consider why scientists could not be sure that the genetic changes were a result of the radiation. Candidates found this question difficult with many failing to attempt the question. Incorrect answers included suggestions about evolution or that the butterflies had come from elsewhere, rather than identifying that there were other factors that could be responsible for the mutations. Those candidates that did recognise that evidence was key to identifying radiation as a cause often failed to gain a mark as they stated that there was no evidence rather than a lack of evidence. Many candidates had misunderstood the correlation aspect of this question.

Question			Answer/Indicative content	Marks	Guidance
	c		*any three from*: variation / AW (1) gives a (selective) advantage / idea of **better** adapted (1) individuals more likely to survive (1) **more likely** to reproduce (1) passes the gene / characteristic / genetic change / mutation (on to its offspring) (1) OR gives a (selective) disadvantage / less well adapted (1) individuals less likely to survive (1) won't reproduce(1) cannot pass the gene / characteristic / genetic change / mutation on to its offspring (1)	3	variation must be within the original population accept a specific example of selective advantage e.g bigger wings if no credit is given for advantage and survival points award 1 mark for survival of the fittest accept a specific example of selective disadvantage e.g no wings Examiner's Comments Again candidates found this question challenging. Candidates were unable to demonstrate an understanding of natural selection. Those that did gain marks for this question often gave an example of natural selection and seemed to find it easier to describe the process within a context that they had learned about. Some candidates incorrectly discussed selective breeding.
			Total	8	

Question			Answer/Indicative content	Marks	Guidance
6			[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 six-mark extended-writing question was common with the Higher Tier and, as anticipated, candidates found this extended writing question the most difficult. Many candidates did not have a good grasp of the processes of selective breeding and natural selection and as a result found talking about their similarities and differences problematic. Many candidates gained marks for the correct identification of a feature of either natural selection or selective breeding or in many cases features about both. Unfortunately many candidates were unable to develop their answer and make a comparison of the two processes. Common similarities discussed included the correct

Question			Answer/Indicative content	Marks	Guidance
					identification of both as methods of breeding and the processes involving the selection of favourable characteristics. A common difference frequently observed highlighted the human control of selection in selective breeding and the lack of this in natural selection. Some candidates did confuse selective breeding with gene manipulation and IVF.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
7	a		**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 question was common with the higher tier paper. Candidates were asked to explain how evolution produces new species. Many of the candidates who gained marks on this question did so for answers relating to natural selection.

Question			Answer/Indicative content	Marks	Guidance
	b		not breed with other beetles; to produce fertile offspring; **check** DNA; look for similarities / compare with others (in **DNA**)	2	**ignore** reference to comparing characteristics **NB** DNA is unknown = 2 marks **Examiner's Comments** This question asked the candidates to explain how they would prove that an unusual beetle was a new species. Very few candidates gained marks on this, only a few suggested checking the DNA.
			Total	8	

Question			Answer/Indicative content	Marks	Guidance
8	a	i	Any two from: dogs with desirable characteristics are selected (by humans) ✓ these individuals are bred together ✓ to produce offspring with desirable characteristics ✓	2 (AO 2.1 × 2)	<u>Examiner's Comments</u> This AO2 question discriminated well and around two thirds of candidates were able to gain at least one mark, for most often writing about animals with desirable characteristics being chosen by humans. More able candidates then went on to say that these animals were bred together – less able candidates did not develop their ideas sufficiently.
		ii	can cause health problems ✓	1 (AO 1.1)	ALLOW examples of health problems such as heart, joint, breathing or behavioural problems <u>Examiner's Comments</u> This AO1 question assessed knowledge in isolation. Candidates commonly suggested that certain breeds of dog would become extinct due to selective breeding. Few recognised the impact of selective breeding on the health of domesticated animals.
	b		a cockapoo can mate with other dogs to have offspring ✓ (the offspring) are fertile ✓	2 (AO 2.1 × 2)	<u>Examiner's Comments</u> Very few candidates, including the higher ability candidates, seemed to understand this AO2 question which required them to apply their scientific knowledge rather than simply recall the definition of a species. They often stated a cockapoo is still a dog and didn't relate this to the definition of a species. A few candidates did realise that cockerpoos can still breed with other dogs to produce fertile offspring.
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
9		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 × 2)	 Examiner's Comments Most candidates scored one or both marks on this AO1 question. A common incorrect response was that Darwin observed extensive variation within a population of a species.
		ii	natural selection ✓	1 (AO 1.1)	ALLOW survival of the fittest Examiner's Comments This question also assessed objective AO1. Many candidates incorrectly named the theory as evolution with no reference to natural selection.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
10			*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Explanation of how the rat population became resistant to warfarin includes ideas about genetic variant/allele. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Explanation at phenotypic level of how the rat population became resistant to warfarin. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Explains the advantage of resistance and recognises that the change in the population is an example of evolution/adaptation but does not explain how it occurs. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6 (AO 2.1 × 6)	**AO2.2 Applying understanding of natural selection of variants to the context of rats and warfarin resistance** Indicative scientific points at Level 3 may include: • there was genetic variation within the population of rats • a mutation created a genetic variant/allele that gives resistance to warfarin • mutated variant/allele was passed on to offspring when the rat mated/reproduced • over many generations the resistance variant/allele became more common in the population Indicative scientific points at Level 2 may include: • there was variation within the population of rats • at first, one rat was resistant to warfarin • mutation created resistance • resistant rats have an advantage / are better suited to their environment • resistance rat(s) more likely to reproduce (than non-resistant rats) • resistant rats pass on the mutation to their offspring **ALLOW** ref. to passing on the “gene” • over many generations resistance became more common in the population • this is natural selection Indicative scientific points at Level 1 may include: • resistance means the warfarin/poison does not kill/affect the rats • resistance passed on to offspring • the rats evolved/adapted **IGNORE** ‘survival of the fittest’ without explanation

Question			Answer/Indicative content	Marks	Guidance
					Examiner's Comments Ideas about natural selection and adaptation now appear in the curriculum in Key Stages 2 and 3. Candidates should be well practised at explaining changes in the characteristics of populations using these ideas by the time they get to the end of Key Stage 4. The idea that is new to candidates at Key Stage 4 is that natural selection acts at the genetic level, such that genetic variants/alleles that give rise to advantageous phenotypes which are selected and become more common over a number of generations. Candidates were required to demonstrate understanding of this idea to achieve Level 3. Few Level 3 responses were seen, with most candidates operating at Level 2 or Level 1.
			Total	6	