# 1.16 Variation, Evolution and Selection: 1-hour Pack

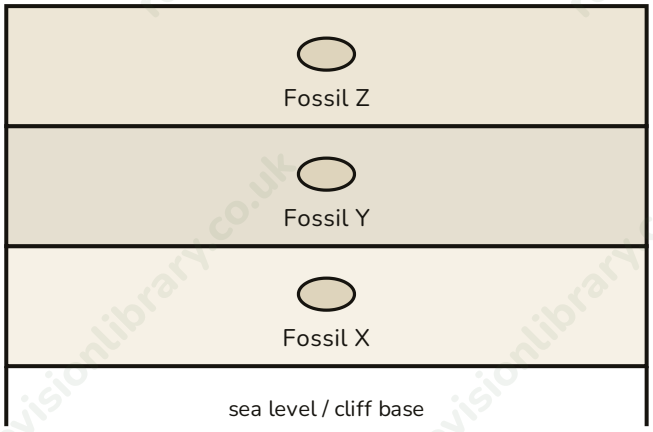
AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

**1** The diagram shows a cross-section through undisturbed layers of sedimentary rock exposed in a coastal cliff near Lyme Regis, in Dorset. Fossils of three different ammonite species, labelled X, Y and Z, were found in three different rock layers: X in the lowest (deepest) layer, Y in the middle layer, and Z in the uppermost (shallowest) layer.




**(a)** Assuming the rock layers have not been disturbed since they formed, state which fossil, X, Y or Z, is the oldest, and explain how you know. **(2)**

**(b)** Very few fossils exist of the earliest forms of life on Earth. Explain why. **(2)**

**(Total for Question 1 is 4 marks)**


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**2** Traditionally, living organisms were classified into five kingdoms. Following advances in biochemical evidence, in particular the analysis of a molecule found in every living cell, Carl Woese proposed a new three-domain system of classification.

**(a)** Name the three domains in Woese's system of classification. **(1)**

**(b)** Name the molecule whose sequence was analysed to provide the evidence for this new system of classification. **(1)**

**(c)** Explain why analysing rRNA gave scientists more reliable evidence for classifying organisms than using only their visible (observable) characteristics. **(2)**

**(Total for Question 2 is 4 marks)**


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**3** Scientists can use genetic engineering to insert a gene from one organism into the genome of a different organism. Golden Rice is a genetically engineered variety of rice that has been modified to produce β-carotene (which the body converts to vitamin A) in its grains. It has been proposed as a way of reducing vitamin A deficiency in parts of the world where rice is a staple food and vitamin A deficiency is common, but its introduction has been debated and delayed for many years. Evaluate the benefits and risks of using genetic engineering to produce crops such as Golden Rice.

**(Total for Question 3 is 6 marks)**

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**4** A dairy farmer near Penrith, in Cumbria, wants to breed a herd of cows that produce a higher yield of milk.

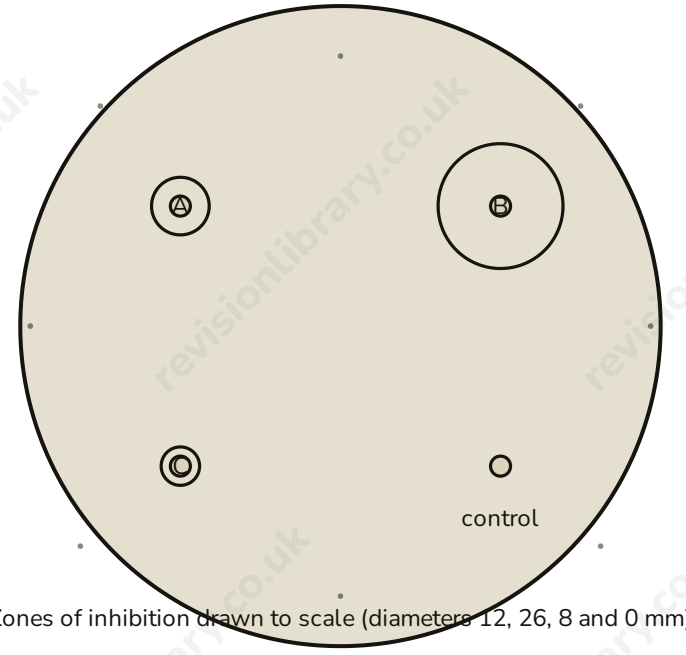
**(a)** Describe how the farmer could use selective breeding, over several generations, to produce a herd of high milk-yielding cows. **(4)**

**(b)** Name the process described in part (a). **(1)**

**(Total for Question 4 is 5 marks)**


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**5** Ffion investigated the effect of three different antibiotic discs (A, B and C) on the growth of a culture of harmless bacteria, using aseptic technique. Each antibiotic disc was placed on an agar plate that had been evenly spread with the bacteria, then incubated at 25°C for 48 hours. After incubation, a clear zone (no bacterial growth) had formed around each disc. Results: disc A, clear zone diameter 12 mm; disc B, clear zone diameter 26 mm; disc C, clear zone diameter 8 mm; control disc (no antibiotic), clear zone diameter 0 mm.




Zones of inhibition drawn to scale (diameters 12, 26, 8 and 0 mm)

**(a)** State two precautions Ffion should take when handling the bacterial culture, in order to prevent contamination of the culture or to prevent harm to herself. **(2)**

**(b)** Explain why the plate was incubated at a maximum temperature of 25°C, rather than 37°C (human body temperature). **(1)**

**(c)** Calculate the area of the clear zone produced by antibiotic disc B. Use the equation: area of a circle = $\pi \times r^2$. Use $\pi = 3.14$. Give your answer to 3 significant figures. **(2)**


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**(d)** Ffion concluded that antibiotic disc B was the 'strongest' antibiotic because it produced the largest clear zone. Evaluate this conclusion. **(2)**

**(e)** Explain the purpose of including the control disc (no antibiotic) in this investigation. **(1)**

**(f)** Ffion repeated the investigation three times for each antibiotic disc and calculated a mean zone diameter. Suggest why this improves the reliability of her results. **(2)**

**(g)** Ffion wants to test whether increasing the concentration of antibiotic B increases the diameter of its clear zone. Describe one change to the method needed to test this, and identify the independent variable. **(2)**

**(h)** Explain why it was important that the agar plate was spread evenly with the same concentration of bacteria before the discs were added. **(2)**

**(Total for Question 5 is 14 marks)**


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**6** A plant breeder wants to develop a variety of wheat that is more resistant to a fungal disease that currently reduces crop yields.

**(a)** Describe how the breeder could use selective breeding, over several generations, to develop a wheat variety with improved disease resistance. **(4)**

**(b)** Selective breeding for disease resistance can reduce the genetic variation within a wheat population. Explain why this could be a disadvantage in the future. **(2)**

**(Total for Question 6 is 6 marks)**

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**7** Bacteria can be genetically engineered to produce human insulin, which is used to treat people with type 1 diabetes. Describe how a bacterium can be genetically engineered to produce human insulin.

**(Total for Question 7 is 5 marks)**

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**8** MRSA (meticillin-resistant Staphylococcus aureus) is a strain of bacteria that is resistant to many antibiotics, including meticillin. Use the theory of natural selection to explain how a population of bacteria can become resistant to an antibiotic such as meticillin.

**(Total for Question 8 is 6 marks)**


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# Mark scheme · 1.16 Variation, Evolution and Selection: 1-hour Pack

## Question 1

(a) X is the oldest **B1**

(a) because, in undisturbed sedimentary rock, the lowest/deepest layers were deposited first (formed longest ago), so fossils found in the lowest layer must be the oldest, oe **B1**

**(a) Answer: X is the oldest, because in undisturbed rock the lowest layers formed first, so contain the oldest fossils.**

(b) many early life forms were soft-bodied and had no hard parts (such as bone, shell or teeth), so they decayed away completely and left few or no traces to be preserved as fossils **B1**

(b) many of the rocks that did contain early fossils have since been destroyed by geological activity (e.g. heat, pressure, erosion) over the vast amount of time that has passed, oe **B1**

**(b) Answer: Most early life was soft-bodied, so it decayed without leaving traces; also, much of the rock that did contain early fossils has since been destroyed by geological processes.**

## Question 2

(a) Archaea, Bacteria and Eukaryota (all three needed for the mark), oe **B1**

**(a) Answer: Archaea, Bacteria and Eukaryota.**

(b) ribosomal RNA (rRNA) **B1**

**(b) Answer: Ribosomal RNA (rRNA).**

(c) organisms can look similar, or different, due to factors such as convergent evolution or the environment affecting appearance, so this does not necessarily reflect how closely related they actually are **B1**

(c) rRNA (molecular) evidence directly reflects genetic/evolutionary relatedness between organisms, and can reveal similarities or differences that are not visible from appearance alone, oe **B1**

**(c) Answer: Appearance can be misleading, as similar features can evolve independently or be affected by environment, whereas rRNA sequences directly reflect genetic relatedness, revealing relationships not visible from appearance alone.**

## Question 3

**Level 3** A clear, well-linked evaluation is given of both benefits and risks, leading to a justified conclusion. The answer shows a good understanding of the underlying science and of the wider ethical/social issues involved. **5-6**

**Level 2** Benefits and risks are both described, showing some understanding of the science and/or ethical issues involved. There is some linking of ideas, but the evaluation or conclusion may be one-sided or underdeveloped. **3-4**

**Level 1** Simple, largely unlinked statements are made about a benefit or a risk. The answer may be one-sided, with little evaluation or scientific detail. **1-2**

**Level 0** No relevant content. **0**

**Indicative content:**

- Benefit: could prevent vitamin A deficiency, which can cause blindness and can be fatal, especially in children, in populations whose diets are low in vitamin A.
- Benefit: genetic engineering is much faster than selective breeding at introducing a new characteristic, and can introduce genes from a completely different species, which selective breeding cannot do.
- Benefit: genetically engineered crops could increase yield or resistance to pests or disease, reducing pesticide use and helping food security.
- Risk: the long-term effects of eating GM crops, or of GM genes spreading into wild relatives through cross-pollination, are not yet fully known.
- Risk: GM seed may be more expensive, and patented/owned by large companies, making farmers dependent on buying new seed each year rather than saving their own.
- Risk/ethical: some people have religious, cultural or personal ethical objections to modifying the genomes of living organisms.
- Risk: if a single GM variety replaces many traditional varieties, this could reduce biodiversity (monoculture).
- A reasoned conclusion should weigh the benefits (such as preventing vitamin A deficiency) against the risks (such as uncertainty and cost), and may reasonably come down on either side provided it is supported by the points made.


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## Question 4

(a) select the highest milk-yielding cows and a bull with high genetic merit for milk production in his daughters **B1**

(a) breed the selected cows with the selected bull **B1**

(a) select the highest milk-yielding daughters and bulls with high genetic merit for their daughters' milk production as parents for the next generation **B1**

(a) repeat this selection and breeding process over many generations, until the desired milk yield is reached in most/all of the herd, oe **B1**

**(a) Answer: Select the highest milk-yielding cows and a bull with high genetic merit for his daughters' milk production, then breed them. Select the highest-yielding daughters and bulls with high genetic merit for their daughters' milk production as parents for the next generation. Repeat this selection and breeding process over many generations.**

(b) selective breeding (artificial selection) **B1**

**(b) Answer: Selective breeding (artificial selection).**

## Question 5

(a) sterilise the inoculating loop/spreader before and after use (e.g. by passing it through a Bunsen burner flame) **B1**

(a) any second valid precaution, e.g. work near a Bunsen burner flame to create an updraught, tape (do not fully seal) the lid of the Petri dish, or wash hands/disinfect surfaces before and after, oe; any two for 2 marks **B1**

**(a) Answer: For example, sterilise the inoculating loop before and after use, and tape rather than fully seal the lid of the Petri dish.**

(b) to prevent/reduce the growth of pathogens that could be harmful to humans, which grow best near human body temperature, oe **B1**

**(b) Answer: To reduce the growth of pathogens that could harm humans, which grow best at human body temperature.**

(c) radius = 26 / 2 = 13 (mm); correct substitution shown: $3.14 \times 13^2$ **M1**

(c) 531 $mm^2$ cao (3 s.f.) **A1**

**(c) Answer: 531 $mm^2$ (3 s.f.)**

(d) a larger zone does suggest disc B was more effective against this species of bacteria, under these conditions **B1**

(d) however, this conclusion is only valid if all three discs contained the same concentration of antibiotic and diffused into the agar at a similar rate; if the concentrations differed, the comparison would not be fair, oe **B1**

**(d) Answer: A larger zone does suggest greater effectiveness, but the comparison is only valid if all discs contained the same concentration of antibiotic and diffused at similar rates.**

(e) to show that any clear zones around the antibiotic discs were caused by the antibiotic, and not by another factor such as the paper disc itself or the general growth conditions, oe **B1**

**(e) Answer: It shows that any clear zones on the other discs are caused by the antibiotic itself, not by some other factor.**

(f) repeating reduces the effect of anomalous results/random error **B1**

(f) a mean is more representative of the true effect of the antibiotic, increasing confidence that the pattern observed is a genuine effect rather than due to chance, oe **B1**

**(f) Answer: Repeats reduce the effect of random error or anomalies; the mean is more representative of the antibiotic's true effect, increasing reliability.**

(g) use discs soaked in a range of different concentrations of antibiotic B, keeping all other variables the same (e.g. same bacteria species, temperature and incubation time) **B1**

(g) independent variable = concentration of antibiotic (on the disc) **B1**

**(g) Answer: Test discs soaked in a range of concentrations of antibiotic B, keeping all other variables constant; the independent variable is the concentration of antibiotic.**

(h) so that any difference in the size of the clear zones is due to the effectiveness of the antibiotics (a fair test) **B1**

(h) rather than being due to a difference in the starting number/concentration of bacteria on different parts of the plate, oe **B1**

**(h) Answer: So any difference in zone size is due to antibiotic effectiveness (a fair test), rather than an uneven starting concentration of bacteria on the plate.**


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## Question 6

(a) select the individual wheat plants from the current population that show the greatest natural resistance to the disease, oe **B1**

(a) breed these selected, more resistant plants together, oe **B1**

(a) select the most disease-resistant offspring from this generation, oe **B1**

(a) repeat this process of selecting and breeding the most resistant individuals over many generations, until most/all plants in the population show strong disease resistance, oe **B1**

**(a) Answer: Select the wheat plants showing the greatest natural disease resistance, breed them together, select the most resistant offspring, then repeat this selection and breeding process over many generations until most plants show strong resistance.**

(b) reduced genetic variation means there are fewer different alleles present in the population, oe **B1**

(b) this makes the population less able to adapt if a new disease, pest or environmental change (e.g. a new strain of the fungus) appears, because fewer individuals are likely to already carry a useful resistance allele, risking the whole crop, oe **B1**

**(b) Answer: Reduced genetic variation means fewer different alleles are present in the population, making it less able to adapt if a new disease, pest, or environmental change appears, since fewer individuals are likely to already carry a useful resistance allele, putting the whole crop at risk.**

## Question 7

the gene for human insulin is identified and cut out of human DNA, usually using a restriction enzyme, oe **B1**

a plasmid (a small circular piece of bacterial DNA) is removed from a bacterium and cut open using the same restriction enzyme, leaving matching/complementary ends, oe **B1**

the insulin gene is inserted into the cut plasmid and joined together using an enzyme called ligase, forming recombinant DNA, oe **B1**

the recombinant plasmid (acting as a vector) is inserted into a new bacterial cell, oe **B1**

the genetically modified bacteria are cultured/grown in large numbers (e.g. in fermenters), where they express the inserted gene and produce human insulin, which is then extracted and purified, oe **B1**

**Answer: The insulin gene is cut from human DNA and a bacterial plasmid is cut open, both using the same restriction enzyme; the gene is inserted into the plasmid using ligase to form recombinant DNA; the recombinant plasmid (vector) is inserted into a bacterium, which is cultured in large numbers to express and produce human insulin.**

## Question 8

within a bacterial population there is variation; some bacteria already carry a mutation/allele giving resistance to the antibiotic, before the antibiotic is ever used **B1**

when the antibiotic is used, non-resistant bacteria are killed **B1**

resistant bacteria survive (are not killed) and face less competition for resources such as nutrients and space **B1**

resistant bacteria reproduce (by binary fission), passing the resistance allele/gene on to their offspring **B1**

because bacteria reproduce rapidly, the resistant allele/population increases in frequency quickly, over successive generations **B1**

eventually most/all of the population becomes resistant to the antibiotic, oe; award any 6 of the marking points, max 6 **B1**

**Answer: Existing variation means some bacteria already carry a resistance mutation; the antibiotic kills non-resistant bacteria; resistant bacteria survive with less competition and reproduce, passing on the resistance allele; because bacteria reproduce so quickly, the resistant allele spreads through the population over successive generations until most bacteria are resistant.**


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