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EDEXCEL GCSE BIOLOGY: QUESTIONS BY TOPIC

Natural Selection and Genetic Modification (4)

GCSE Biology (Higher) Topic 4

9 questions · 91 marks · Mark schemes included

Pearson Edexcel GCSE (9-1) Biology 1BI0, Higher Tier, June 2018 - June 2025

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HOW TO USE THIS BOOKLET

Questions run from the lowest mark tariff to the highest, so similar questions sit together.

Click any row below to jump straight to that question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

9 questions · 91 marks · lowest tariff first



7-MARK QUESTIONS

1 question in this booklet



1 (a) (i) Which process is involved in the theory of evolution?

(1)

- ☐ A genetic engineering
- ☐ B biological control
- ☐ C natural selection
- ☐ D tissue culture

(ii) Figure 1 shows some stages of the theory of evolution.

overproduction → variation → survival of the fittest

Figure 1

State **two** causes of variation in organisms.

(2)

1

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2

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(iii) Disease is an example of a selection pressure.

Give **one** other example of a selection pressure that leads to survival of the fittest.

(1)

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- (b) Figure 2 shows the location of the Wallace line, an imaginary line Alfred Wallace suggested, based on his research.

Wallace found that animals to the west of the line were different from animals to the east of the line.



(Source: <https://www.dailymail.co.uk/sciencetech/article-4279382/Animal-evolution-shaped-movements-Earth.html>)

Figure 2

- (i) Suggest **two** possible reasons why animals to the west of the Wallace line are different from animals to the east of the Wallace line.

(2)

1

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2

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- (ii) Give **one** reason why the work of Alfred Wallace encouraged Charles Darwin to publish his theory of evolution.

(1)

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(Total for Question 1 = 7 marks)

9-MARK QUESTIONS

3 questions in this booklet



5 Figure 5 shows a great tit on a bird feeder.



© taviphoto/Shutterstock

Figure 5

Scientists have found that great tits living now have longer beaks than great tits living 50 years ago.

Genetic analysis shows changes in the sequence of the bird's DNA.

(a) (i) Give the complementary strand sequence for this DNA template.

(1)

A	T	G	T	T	A	C	G	T
:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:

(ii) Which statement correctly describes a DNA molecule?

(1)

- ☐ **A** two strands joined together by strong bonds to form a double helix
- ☐ **B** two complementary bases twisted into a double helix by strong bonds
- ☐ **C** a double helix with strands joined by hydrogen bonds between bases
- ☐ **D** four complementary strands joined together with hydrogen bonds

(iii) State the term used to describe a change in the sequence of DNA bases.

(1)

- (b) Scientists think that great tits living now have longer beaks because of the increased use of bird feeders during the last 50 years.

Explain how natural selection could have caused an increase in beak length because of the use of bird feeders.

(4)

- (c) Birds are classified in the domain Eukarya.

- (i) Why are the cells from birds described as eukaryotic?

(1)

- ☐ **A** they have membrane-bound organelles
- ☐ **B** they do not have nuclei
- ☐ **C** they have a rigid cell wall
- ☐ **D** they have a cell membrane

- (ii) Give **one** reason why the three domain classification system was proposed.

(1)

(Total for Question 5 = 9 marks)



5 (a) In 2017, a new strain of *Klebsiella pneumoniae* bacteria was discovered that was resistant to 26 different antibiotics.

(i) Explain how *Klebsiella pneumoniae* bacteria developed resistance to antibiotics.

(4)

(ii) State how the use of antibiotics could contribute to *Klebsiella pneumoniae* bacteria developing resistance to antibiotics.

(1)

(iii) *Klebsiella pneumoniae* is a prokaryotic cell.

Which is a characteristic feature of a prokaryotic cell?

(1)

- ☐ **A** it has chloroplasts
- ☐ **B** it does not have a nucleus
- ☐ **C** it does not have ribosomes
- ☐ **D** it cannot reproduce without a host



- (b) New antibiotics are being developed to treat the disease caused by *Klebsiella pneumoniae*.

Describe the stages of antibiotic development that would occur after the discovery of a new antibiotic.

(3)

(Total for Question 5 = 9 marks)

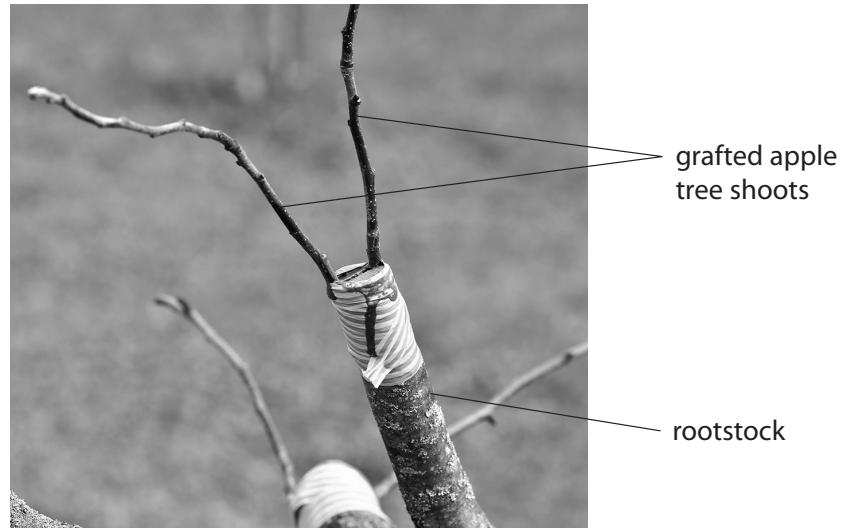


2 (a) Name the type of reproduction that produces genetically identical organisms.

(1)

(b) Grafting is a technique used to grow some varieties of apple tree.

Figure 3 shows apple tree shoots grafted on to a rootstock.



(Source: © ATTILA Barsan/Shutterstock)

Figure 3

Grafting can be used to produce apple trees that are genetically identical.

Give **one** advantage and **one** disadvantage of growing genetically identical apple trees.

(2)

advantage

disadvantage

(c) As apples ripen, enzymes convert starch into sugars.

Devise a method to find the optimum pH of an enzyme that breaks down starch.

You may use standard laboratory equipment and the solutions listed in the box.

starch solution enzyme solution iodine solution
a range of pH solutions

(4)

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(d) The optimum pH of an enzyme is pH 6.

Explain why this enzyme would not work at pH 10.

(2)

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(Total for Question 2 = 9 marks)



10-MARK QUESTIONS

1 question in this booklet



- 8** Alfred Russel Wallace travelled around Malaysia during the 1800s and wrote to Charles Darwin about the animal species he studied.

His main conclusions were very similar to those of Charles Darwin and they both contributed to the current understanding of evolution.

- (a) Describe the theory of evolution by natural selection.

(3)

- (b) Wallace and Darwin did not always agree.

Darwin believed that male birds have feathers that are brightly coloured to make them more attractive to female birds.

Wallace thought that female birds have feathers that are less brightly coloured so they are more likely to survive.

- (i) Explain why having feathers that are less brightly coloured increases the survival rate of females.

(2)



- (ii) Suggest why it is more important for the survival of the species that the survival rate is higher in female birds than in male birds.

(2)

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- (c) Figure 7 shows the limbs of five animals.

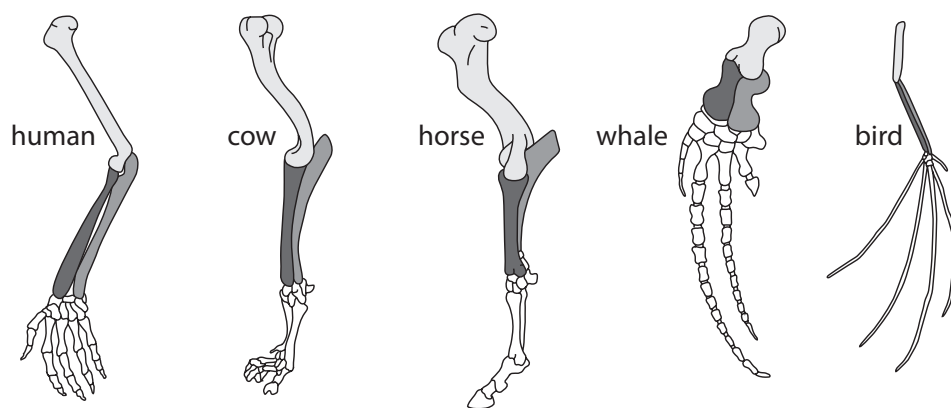


Figure 7

Describe how the structure of these limbs provides scientists with evidence for evolution.

(3)

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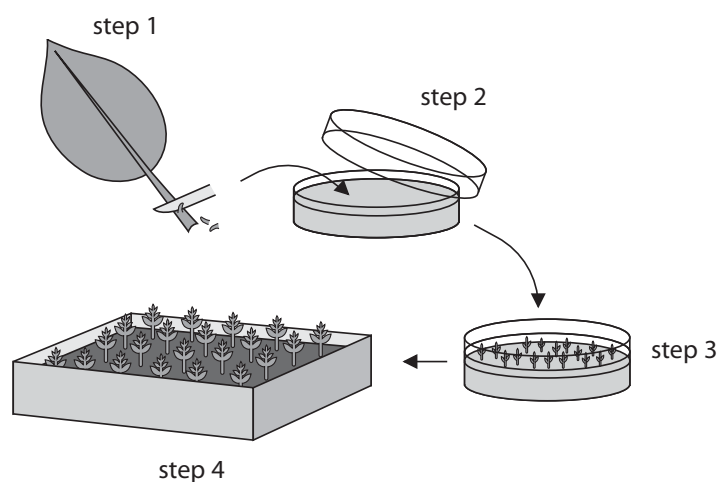
(Total for Question 8 = 10 marks)

11-MARK QUESTIONS

2 questions in this booklet



- 4 (a) Figure 8 shows a method of producing plants.



Step 1. Cells taken from parent plant.

Step 2. Cells placed on agar growth medium.

Step 3. Cells develop into tiny plantlets.

Step 4. Plantlets grown in compost.

Figure 8

- (i) Some cells in each plantlet develop into root cells.

Name the process occurring as these cells develop into root cells.

(1)

- (ii) Describe the advantages of producing plants by the method shown in Figure 8.

(2)



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(iii) An autoclave is used to prepare the agar growth medium used in Step 2.

Explain why the agar growth medium is autoclaved.

(2)

(iv) One of the plantlets had different coloured leaves.

Give **one** reason why this plantlet had different coloured leaves.

(1)



13



(b) Crop plants provide a source of energy in the form of carbohydrates such as starch and sugars.

(i) Describe the test to identify starch.

(2)

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14



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- (ii) The amount of energy in the sugars extracted from crop plants can be measured using the calorimeter shown in Figure 9.

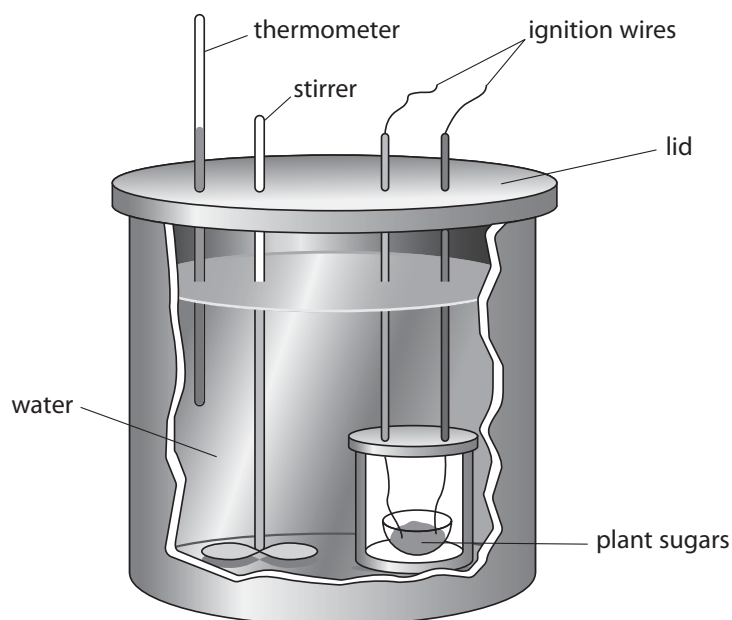


Figure 9

Explain why the calorimeter has a lid.

(2)

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- (iii) State why it is important to stir the water in the calorimeter.

(1)

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(Total for Question 4 = 11 marks)

- 7 (a) Figure 13 shows the pentadactyl limb of a bat and a cat.

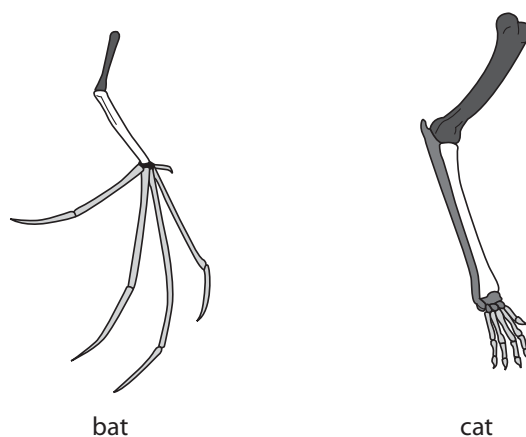


Figure 13

- (i) Describe the reasons why the anatomy of the pentadactyl limb suggests that bats and cats evolved from a common ancestor.

(2)

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- (ii) Genetic analysis also provides evidence for evolution.

Scientists can sequence genes from different organisms.

Describe how this type of genetic analysis provides evidence for evolution.

(2)

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(b) Mendel's research on pea plants showed that genetic traits are inherited.

(i) Which term is used to describe the expression of traits in an organism?

(1)

- ☐ A genotype
- ☐ B phenotype
- ☐ C allele
- ☐ D gamete

(ii) Mendel crossed pea plants that produced round seeds with pea plants that produced wrinkled seeds.

All the offspring produced round seeds.

He then crossed these offspring with each other.

Some pea plants in the next generation produced round seeds and the others produced wrinkled seeds.

Explain how this showed that some inherited traits are not expressed in an organism.

(3)

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23



- (c) Duchenne muscular dystrophy is a recessive sex-linked genetic disorder. This disorder causes muscle weakness.

Figure 14 shows the inheritance of Duchenne muscular dystrophy in a family.

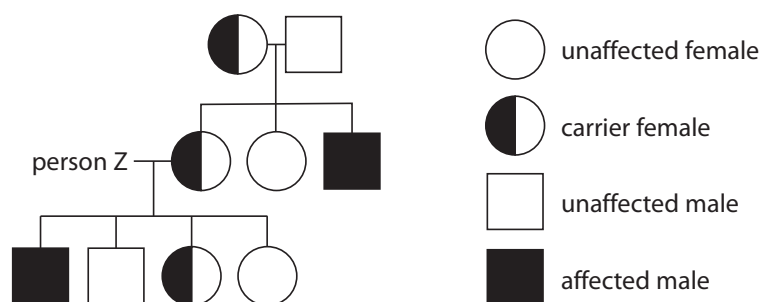


Figure 14

State and explain the phenotype of person Z.

(3)

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(Total for Question 7 = 11 marks)

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12-MARK QUESTIONS

1 question in this booklet



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- 9 (a) Yeast cells can be genetically modified to produce a painkiller.

This painkiller is usually obtained from opium poppies.

One method for genetically modifying a yeast cell uses a plasmid containing the desired gene.

- (i) Explain how a gene can be inserted into a plasmid.

(2)

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- (ii) Discuss the possible benefits and risks of producing painkillers from genetically modified yeast cells rather than extracting the painkillers from poppies.

(3)

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(b) Figure 17 shows the structure of a DNA nucleotide.

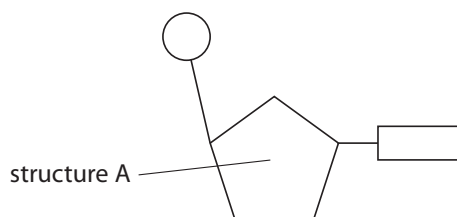


Figure 17

(i) Structure A is a

- ☒ **A** base
- ☒ **B** phosphate
- ☒ **C** sugar
- ☒ **D** polymer

(1)

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* (ii) In 2003, the first complete human genome was sequenced.

The genomes of different people have small changes in the sequence of the DNA bases.

Describe how these changes in DNA sequence can affect the individuals and how sequencing a person's genome could influence their medical treatments.

(6)

(Total for Question 9 = 12 marks)



13-MARK QUESTIONS

1 question in this booklet



9 There is a shortage of kidneys for organ transplants.

Scientists are investigating how to grow kidneys using genetically modified pig embryos.

Figure 8 shows this process.

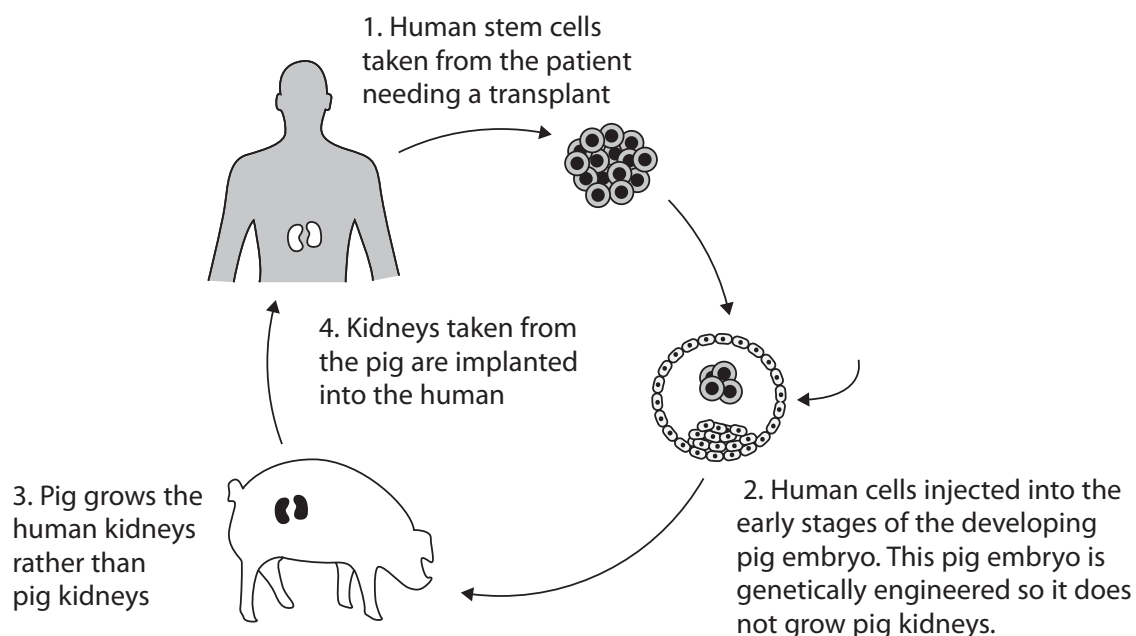


Figure 8

- (a) (i) State why the embryo of the pig must be engineered so it does not grow pig kidneys.

(1)

- (ii) Explain why human stem cells are used for this process.

(2)

- (b) Figure 9 shows the number of organ transplants needed and the number of donors available in the USA from 1991 to 2018.

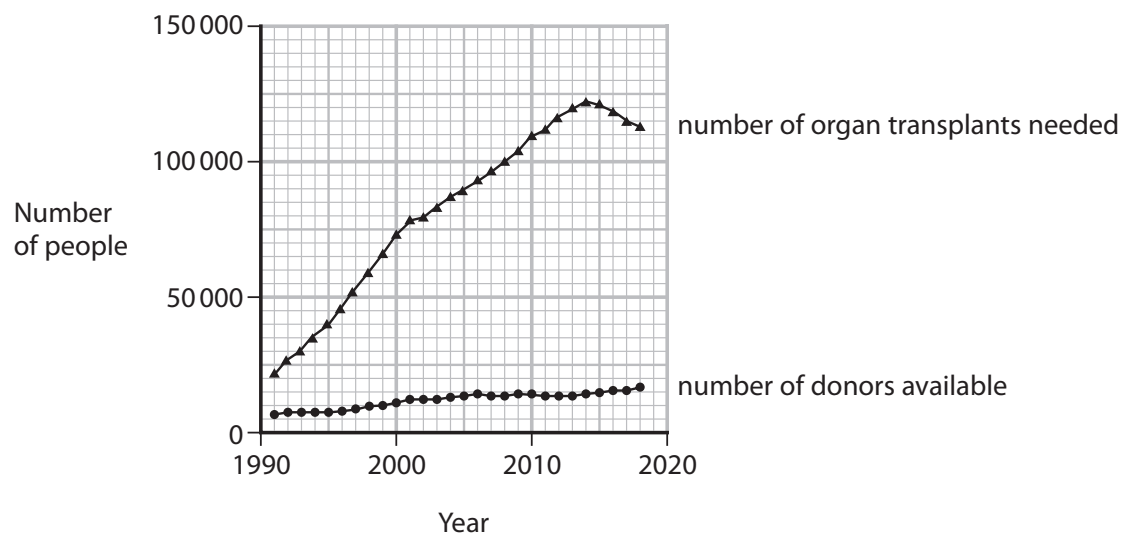


Figure 9

- (i) Compare the number of donors available with the number of organ transplants needed from 1991 to 2018.

Use information from the graph to support your answer.

(3)

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- (ii) State why scientists are genetically engineering animals for organ transplants.

(1)

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*(c) Bacteria have been genetically engineered to produce human insulin since 1978.

Explain how bacteria can be genetically engineered to produce human insulin.

(6)

(Total for Question 9 = 13 marks)



MARK SCHEMES

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Question number	Answer	Mark
1(a)(i)	C natural selection The only correct answer is C <i>A is not correct because genetic engineering is not involved in the theory of evolution</i> <i>B is not correct because biological control is not involved in the theory of evolution</i> <i>D is not correct because tissue culture is not involved in the theory of evolution</i>	(1) AO1 1

Question number	Answer	Additional guidance	Mark
1 (a)(ii)	Two from: - genetics / mutation / alleles (1) - sexual reproduction / meiosis (1) - environment / named environmental factors e.g. diet, lifestyle, climate, temperature (1)	accept genes / genetic modification ignore DNA accept idea of different parents / breeding ignore inbreeding / selective breeding accept changes to the environment ignore adaptations to environment / selection pressures / / natural selection / disease	(2) AO1 1

Question number	Answer	Additional guidance	Mark
1(a)(iii)	Any one from: • change in the environment • competition • (increase in) predators • change in {prey / food source / resources / habitat} • natural disaster	accept {climate / weather} change accept use of antibiotics / named chemicals e.g. pesticides accept idea of availability of / decrease in ignore bacteria / pathogens / named pathogens	(1) AO1 1

Question number	Answer	Additional guidance	Mark
1(b)(i)	An answering including two from: • (different) mutations occurred (1) • selection pressure (1) • different {environments / climate / habitats / ecosystems} (1)	accept different weather / temperature / conditions	(2) AO2 1

Question number	Answer	Additional guidance	Mark
1(b)(ii)	One from: - his results {were similar / backed-up the work of Darwin / provided more evidence} - Darwin wanted to get the credit - he showed that animal populations {adapt/evolve} (to their environment) - he showed that animals have evolved from common ancestors	accept idea of it being a form of peer review accept they agreed with each other accept {selection pressure / environment} causes differences in characteristics	(1) AO1 1

(Total for question 1 = 7 marks)

Question number	Answer	Additional guidance	Mark																																				
5(a)(i)	<table><tr><td>A</td><td>T</td><td>G</td><td>T</td><td>T</td><td>A</td><td>C</td><td>G</td><td>T</td></tr><tr><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td></tr><tr><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td></tr><tr><td>T</td><td>A</td><td>C</td><td>A</td><td>A</td><td>T</td><td>G</td><td>C</td><td>A</td></tr></table> accept lower case letters	A	T	G	T	T	A	C	G	T	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	T	A	C	A	A	T	G	C	A		(1)
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Question number	Answer	Mark
5(a)(ii)	C a double helix with strands joined by hydrogen bonds between bases The only correct answer is C <i>A is not correct because DNA strands are not held together with strong bonds</i> <i>B is not correct because complementary bases do not form the helix</i> <i>D is not correct because there are two complementary strands</i>	(1)

Question number	Answer	Additional guidance	Mark
5(a)(iii)	Mutation	accept genetic modification / genetic engineering / insertion / deletion / substitution	(1)

Question number	Answer	Additional guidance	Mark
5(b)	An explanation linking four of the following: - the population of great tits shows variation (1) - bird feeders provide a selection pressure (1) - birds with longer beaks {can feed from bird feeders/get more food} (1) - these birds are more likely to {survive/ reproduce} / survival of the fittest (1) - pass the {allele/gene /characteristic} for long beaks to their offspring (1) - over many generations the beak length of the bird population increases (1)	accept there is a mutation that leads to some birds having longer beaks accept there is competition for food / birds with longer beaks outcompete accept birds with shorter beaks can't get food accept birds with shorter beaks die out accept offspring have long beaks accept the process continues/repeats itself	(4)

Question number	Answer	Mark
5(c)(i)	A they have membrane-bound organelles The only correct answer is A B is not correct because they have a nucleus C is not correct because they do not have a cell wall D is not correct because this is not a specific feature of eukaryotic cells	(1)

Question number	Answer	Additional guidance	Mark
5(c)(ii)	genetic analysis / based on {DNA/genetics} / DNA of Archaea more similar to eukaryotes (1)	accept more knowledge because of better microscopes	(1)

(Total for question 5 = 9 marks)



Question number	Answer	Additional guidance	Mark
5(a)(i)	An explanation including four of the following: • by natural selection / evolution (1) • mutation in the bacterium / variation in the population (1) • only the resistant bacteria survived treatment by antibiotics / resistant bacteria survive when people don't finish the course (1) • the resistant bacteria {reproduce / divide} (1) • offspring inherit the resistance / resistance passed onto future generations / process repeats increasing level of resistance (1)	accept <i>Klebsiella</i> for bacteria accept they evolve accept some bacteria have a {gene/allele} for antibiotic resistance accept non-resistant bacteria killed by antibiotics ignore offspring are identical	(4) A02 1

Question number	Answer	Additional guidance	Mark
5(a)(ii)	people not completing their course of antibiotics/overuse of antibiotics	accept acted as a selection pressure accept being used to treat viruses/examples ignore misuse unqualified	(1) A01 1

Question number	Answer	Mark
5(a)(iii)	B it does not have a nucleus The only correct answer is B <i>A is incorrect because prokaryotic cells do not have chloroplasts</i> <i>C is incorrect because prokaryotic cells have ribosomes</i> <i>D is incorrect because prokaryotic cells can reproduce without a host</i>	(1) AO1 1

Question number	Answer	Additional guidance	Mark
5(b)	A description including three of the following: - the antibiotic would go through a development phase (1) - pre-clinical (stage / trials) (1) - testing on animals / testing <i>in-vitro</i> / on cells (1) - clinical (stage / trials) (1) - testing on (healthy) volunteers / testing on patients (1) - double-blind trials (1)	accept examples of the development phase accept named animals accept a description of double-blind trials e.g. placebo and drug	(3) AO2 1

Total for question 5 = 9 marks



Question number	Answer	Additional guidance	Mark
2(a)	asexual (reproduction)	ignore mitosis reject meiosis accept cloning / binary fission	(1)

Question number	Answer	Additional guidance	Mark
2 (b)	One from advantages: • (fruit) will have desired qualities (1) • can be produced faster (1) AND One from disadvantages: • susceptible to a disease (1) • can't survive an environmental change (1) • reduced gene pool (1)	ignore genetically identical / no variation for advantages and disadvantages accept examples of characteristics e.g. all tasty / same taste ignore higher yield accept inherited / genetic diseases accept can't survive a selection pressure	(2)

Question number	Answer	Additional guidance	Mark
2(c)	A method including four from: • mix starch, enzyme and pH (solution) (1) • use iodine (to test for starch) (1) • (with iodine solution) blue-black means starch is present / {orange / brown} means no starch present (1) • control of one variable e.g. concentration, volume, temperature (1) • repeat using different pH solutions (1)	all three solutions are required accept add iodine to a spotting tile ignore blue ignore amount unless a measurement is given	(4)

Question Number	Answer	Additional guidance	Mark
2(d)	An explanation linking two from: • enzyme denatures (1) • which changes the shape of the active site (1) • so {the enzyme cannot bind to its substrate / active site no longer complementary / no enzyme-substrate complexes form} (1)	accept enzyme changes shape accept substrate {no longer fits / is no longer complementary} accept starch for substrate	(2)

(Total for question 2 = 9 marks)

Question number	Answer	Additional guidance	Mark
8(a)	A description including three of the following: • overproduction of offspring (1) • organisms in a species have {variation / mutations} (1) • there is {a struggle for existence / selection pressure / competition} (1) • the adapted organisms survive (1) • (reproduction leads to) offspring inheriting {characteristics / gene / allele / adaptation / trait} (1) • this is repeated over many generations (1)	accept there are differences within {species/organisms} accept named selection pressure /change in the environment accept survival of the fittest accept not adapted organisms die	(3) AO2 1

Question number	Answer	Additional guidance	Mark
8(b)(i)	An explanation including the following: (fewer bright feathers) would be less noticeable / they are camouflaged / they blend in (1) And one from: - therefore they are less likely to be eaten / by predators (1) - therefore more likely to get food / from prey (1)	ignore more likely to survive accept ideas of less likely to be hunted / killed	(2) A02 1

Question number	Answer	Additional guidance	Mark
8(bii)	An answer including the following: - female birds are those who {produce offspring / lay eggs} (1) - one male bird can reproduce with many female birds (1)	accept males do not produce the {offspring / eggs} reject males don't reproduce accept {named species/in rare cases} females can reproduce asexually	(2) A02 1

Question number	Answer	Additional Guidance	Mark
8(c)	A description linking three of the following: - they have a pentadactyl limb (1) - suggesting a common ancestor (1) - that also had a {pentadactyl limb / this limb structure} (1) - how the structure has been adapted to different functions / description of the adaptations for a function (1)	accept they have a similar bone structure / description of the bone structure ignore similar limb structure accept unlikely to have descended from different ancestors	(3) AO1 1

Total for question 8 = 10 marks

Question Number	Answer	additional guidance	Mark
4(a)(i)	differentiation (1)	accept specialisation	(1) AO 2 1

Question Number	Answer		Mark
4(a)(ii)	A logical description including two of the following: • many plants produced (1) • quicker than sexual reproduction (1) • genetically identical/ clones produced (1) • with the desired characteristics (1) • plants from {endangered/rare} plants (1)	accept gives more of that plant/higher yield of that plant ignore plants grow faster obtain plants difficult to grow from seed (1)	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
4(a)(iii)	Any two from: - sterilises agar growth medium (1) - destroys unwanted {bacteria /pathogens/fungi/microorganisms/viruses} /there is no contamination (1) - so microorganisms don't {affect growth of plantlets / don't compete with plantlets/ don't use nutrients needed by plantlets} (1)	ignore prevents microorganisms getting in accept only the plantlets grow	(2) AO 2 2

Question Number	Answer	Additional guidance	Mark
4(a)(iv)	mutation / disease	accept different alleles/ genotypes/genetic variation	(1) AO 2 1

Question Number	Answer	Mark
4(b)(i)	An answer that provides a description by making reference to: - add iodine (solution) (1) - blue-black colour indicates presence of starch (1)	(2) AO 1 2

Question Number	Answer	Additional guidance	Mark
4(b)(ii)	- it is an insulator/reduces heat loss (1) - so energy from sugar is used to heat water / the result is more accurate (1)	accept stops water loss	(2) AO 2 2

Question Number	Answer	Additional guidance	Mark
4(b)(iii)	ensures heat is distributed (evenly) throughout the water (1)	accept all the water is at the same temperature	(1) AO 2 2

Total for Question 4 = 11 marks



Question Number	Answer	Additional guidance	Mark
7(a)(i)	- same structure of bones/examples of bone structure (1) (structure is) unlikely to have occurred more than once during evolution / common ancestor had {the pentadactyl limb structure / similar limb structure} (1)	accept unlikely that different ancestors would have had the same structures	(2) AO 2 1

Question Number	Answer	Additional guidance	Mark
7(a)(ii)	- compare the {genes/sequence of genes} from different organisms (1) - closely related organisms have {more similar/identical} sequences /differences in sequence can show evolution (1)	accept idea of identifying similarities and differences in the {genes/sequences} accept organisms with similar gene sequences share a common ancestor	(2) AO 1 1

Question Number	Answer	Mark
7(b)(i)	B phenotype 1. The only correct answer is B <i>A is not correct because genotype is the combination of alleles</i> <i>C is not correct because an allele is an alternative version of a gene</i> <i>D is not correct because gametes are sex cells</i>	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
7(b)(ii)	An explanation linking three of the following: - the first generation were heterozygous (1) - offspring {needed two wrinkled alleles/are homozygous} to have wrinkled seeds (1) 25% offspring have wrinkled seeds (1) - wrinkled is recessive / round is dominant (1)	accept first generation are carriers accept traits for alleles accept 1 in 4 wrinkled seeds are homozygous recessive = 2 marks accept annotated Punnett squares/ genetic diagrams	(3) AO 2 1

Question Number	Answer		Mark
7(c)	Phenotype: - must be unaffected male (1) Explanation including the following: - he has the dominant allele / males have one copy of the allele as is on the X chromosome (1) (needs a dominant allele) in order to have an unaffected daughter (1)	accept $X^D Y$ (accept any other capital letter) for 1 mark accept a Punnett square to show marking points if annotated.	(3) AO 3 1b AO 3 2a AO 3 2b

Total for Question 7 = 11 marks



Question Number	Answer	Additional guidance	Mark
9(a)(i)	An explanation linking two of the following: - cut the {plasmid/gene/DNA} with a restriction enzyme (1) - insert the gene into the plasmid using ligase (1) - gene and plasmid have the same sticky ends / complementary sticky ends (1)	accept vector for plasmid	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
9(a)(ii)	An evaluation that combines three of the following points: At least one from benefits (yeast grows rapidly) increasing yield (1) - it can be produced in a shorter time period (1) - production is cheaper/easier to extract (1) - takes up less space than growing plants (1) - yeast growth is not weather dependent (1) At least one from risks - concerns over the genetically modified yeast being manufactured illegally (1) - the painkillers may not be identical/as effective (1) - concerns over GM organisms entering environment (1)	Max of 2 marks for benefits. Max of 2 marks for risks. accept possible health risks of painkillers from GM yeast	(3) AO 2 1

Question Number	Answer	Mark
9(b)(i)	C sugar 1. The only correct answer is C <i>A is not correct because the base is the rectangle</i> <i>B is not correct because the phosphate is the circle</i> <i>D is not correct because a polymer is composed of repeated subunits</i>	(1) AO 1 1



Question Number	Indicative content	Mark
*9(b)(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are therefore not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. DNA sequences • DNA has 4 different bases • changes in the DNA are mutations • results in different alleles for these genes • affects the phenotype / produces variation Outcome of DNA sequencing for the individual • identify genetic diseases • identify the risk of developing diseases • impact of knowing that a disease could develop • allow the individual to modify their lifestyle to reduce risk Impact on medical treatment • HGP has determined the location of genes/determined the function of proteins • we have a better understanding of some diseases • take preventative medicine • provide tailor-made medical treatments/personalised medicines	(6) AO 1 1
Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Demonstrates elements of biological understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	• Demonstrates elements of biological understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	• Demonstrates accurate and relevant biological understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Total for Question 9 = 12 marks



Question number	Answer	Additional guidance	Mark
9(a)(i)	Any one from: • pig kidneys cannot be used in humans (1) • pig kidneys would be rejected (by humans) (1) • to prevent competition between the pig and the human organ (1) • so the human kidneys form properly (1)	ignore so it grows human kidneys accept so there is room for the human kidneys	(1) A02 1

Question number	Answer	Mark
9(a)(ii)	An explanation linking two from: • stem cells {are undifferentiated / are unspecialised / can differentiate / become specialised / form any type of cell} (1) • so can produce the {kidney / kidney cells / kidney tissue} (1) • that won't be rejected (when transplanted) (1)	(2) A01 1

Question number	Answer	Additional guidance	Mark
9(b)(i)	A comparison including three of the following: - the number of transplants needed increased rapidly but the number of donors {only increased slightly /remained low} (1) - from {2014 / 2015} the numbers of transplants required decreased (1) - the number of donors available was always lower than the number of transplants needed (1) - comparison of figures from the graph of the number of people needing an organ and donating an organ (1)	accept peaked in {2014 / 2015} accept there are not enough donors for the transplants needed accept a comparative mathematical manipulation of the data	(3) AO3 2ab

Question number	Answer	Mark
9(b)(ii)	not enough donors are available / to increase the number of organs for donation / to meet the demand for organ transplants	(1) AO3 2b

Question number	Indicative content	Mark
9(c)	AO1 - the gene that codes for human insulin is identified - in the human DNA - this is removed using a restriction enzyme - the plasmid of a bacterial cell is removed - using lysosomes/lysozyme - the plasmid is cut open - using (the same) restriction enzyme - leaving complementary sticky ends - the human gene is inserted into the bacterial plasmid - using the enzyme ligase - the plasmid is returned to the bacterial cell - the bacterial cell multiplies	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	- Demonstrates elements of biological understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	- Demonstrates biological understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or underdeveloped. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	- Demonstrates accurate and relevant biological understanding throughout. Understanding of scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well developed structure which is clear, coherent and logical. (AO1)



Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	- A brief understanding of the removal of the human gene or how the bacterial cell is altered - The process described links to the next or a key aspect of the process
Level 2	3–4	- A brief understanding of both the removal of the human gene and the use of a plasmid / bacterial DNA / vector - Linked to the use of at least one correct enzyme
Level 3	5–6	- A clear understanding of the removal of the human gene, the use of the bacterial plasmid including one correct enzyme, and insertion of the (recombinant) plasmid into a bacterium - Linked to the correct enzymes for removal of the gene and the insertion into the plasmid AND the role of sticky ends

Level	Mark	Examples of answers
	0	No rewardable material.
Level 1	1–2	- The human insulin gene is inserted into the bacterial DNA - 1 - Cut the human insulin gene from a cell and insert it into the bacteria - 2 - Cut the human insulin gene leaving sticky ends - 2
Level 2	3–4	- Cut the human insulin gene and cut a plasmid. Insert the gene into the plasmid DNA - 3 - Cut the human insulin gene and cut a plasmid with restriction enzymes. Insert the gene into the plasmid DNA - 4 - Remove the insulin gene using restriction enzymes and cut the plasmid with the same restriction enzyme, Use ligase to insert the gene into the plasmid - 4
Level 3	5–6	- Cut the insulin gene using a restriction enzyme that leaves sticky ends. Cut the plasmid DNA with the same restriction enzyme and insert the gene into the plasmid. Insert the recombinant plasmid back into the bacteria - 5 (no ligase) - Cut the insulin gene using a restriction enzyme. Cut the plasmid DNA with the same restriction enzyme and insert the gene into the plasmid. Insert the recombinant plasmid back into the bacteria - 5 (no sticky ends) - Cut the insulin gene using a restriction enzyme that leaves sticky ends. Cut the plasmid DNA with the same restriction enzyme to leave complementary sticky ends. Join the gene and the plasmid using ligase. Insert the recombinant plasmid back into the bacteria - 6

Total for question 9 = 13 marks

