Gene Expression, Epigenetics and Phenotype (Topic 3): Edexcel SNAB A Level Biology Exam Questions by Topic

20 questions · 62 marks · about 74 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · AS Paper 2 · June 2016 · Q7(c) · 4 marks

(c) Some fish produce another anti-freeze protein, called AFP II.

The tissues of these fish were tested for the presence of AFP II and the mRNA coding for AFP II.

The results are shown in the table.

Molecule	Present in
AFP II protein	all tissues
AFP II mRNA	liver tissue only

Explain the distribution of the AFP II protein and AFP II mRNA.

(4)

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Question 2 · AS Paper 2 · June 2017 · Q7(a)(ii) · 4 marks

(ii) Describe how mesenchymal stem cells can give rise to different types of cell.

(4)

Question 3 · AS Paper 2 · June 2018 · Q2(c) · 3 marks

(c) Extracellular enzymes are produced by specialised cells.

Explain how groups of cells can produce the same enzyme.

(3)

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Question 4 · AS Paper 2 · June 2023 · Q5(b)(i) · 4 marks

(b) The AHRR gene is involved in regulation of cell growth and differentiation.

(i) Explain how differential gene expression allows cells to become specialised.

(4)

Question 5 · A level Paper 2 · June 2019 · Q6(c)(i) · 3 marks

(c) In zone 3, some of the cells differentiate to give rise to phloem sieve tube elements and others differentiate into phloem companion cells.

(i) Explain how genetically identical cells in zone 3 can differentiate to give rise to different tissues.

(3)

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Question 6 · A level Paper 2 · June 2022 · Q5(b)(ii) · 4 marks

(ii) Another adaptation to living at high altitude is to have more red blood cells circulating in their blood.

Explain how a bone marrow stem cell can give rise to red blood cells.

(4)

Question 7 · A level Paper 2 · June 2023 · Q2(b)(ii) · 3 marks

(ii) Describe the effect of lactose on the lac operon.

(3)

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6 The zebrafish (*Danio rerio*) has been studied as a model for vertebrate development.

Zebrafish have a variety of types of stripes and fin shape phenotypes.

Wild type zebrafish are homozygous for the black stripe and short fin phenotypes.

The photograph shows a wild type zebrafish.



(Source: © Mirko_Rosenau/Shutterstock)

(a) The black stripes of zebrafish are produced by cells called melanophores.

Melanophores produce a black pigment called melanin.

Explain how a specialised cell such as a melanophore is produced from a stem cell.

(3)

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Question 9 · A level Paper 1 · June 2025 · Q7(a)(ii) · 2 marks

(ii) After fertilisation, cell division leads to the formation of a blastocyst.

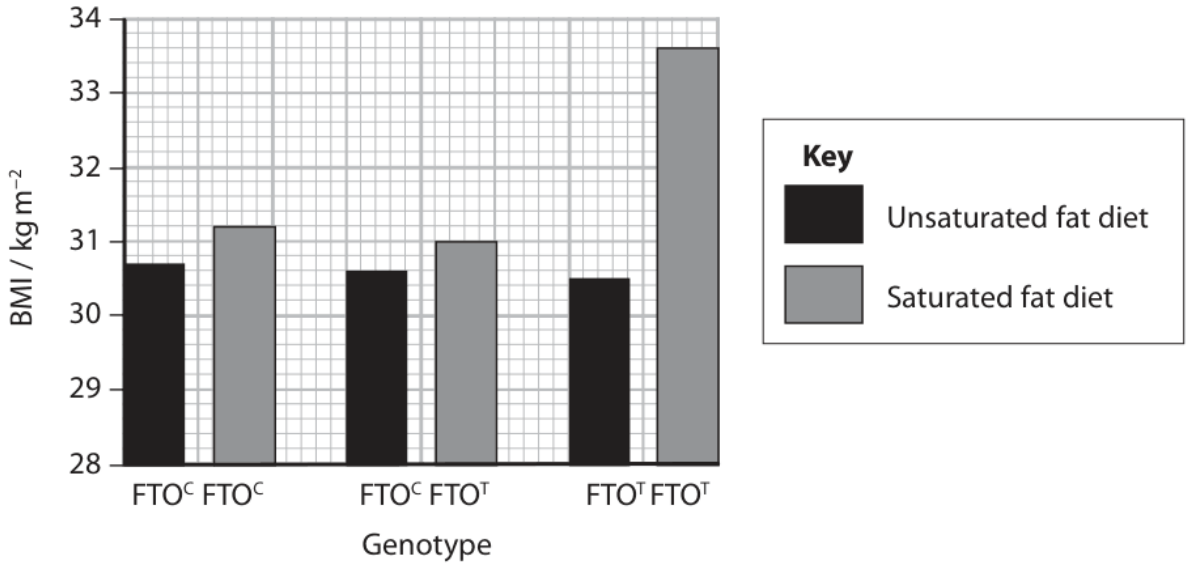
Cells of the blastocyst differentiate to form an embryo.

Describe how cells of the blastocyst differentiate.

(2)

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(b) The effects of saturated fats in the diet on the BMI in individuals with different FTO genotypes are shown in the graph.



Deduce the effect of environmental and genetic factors on BMI.

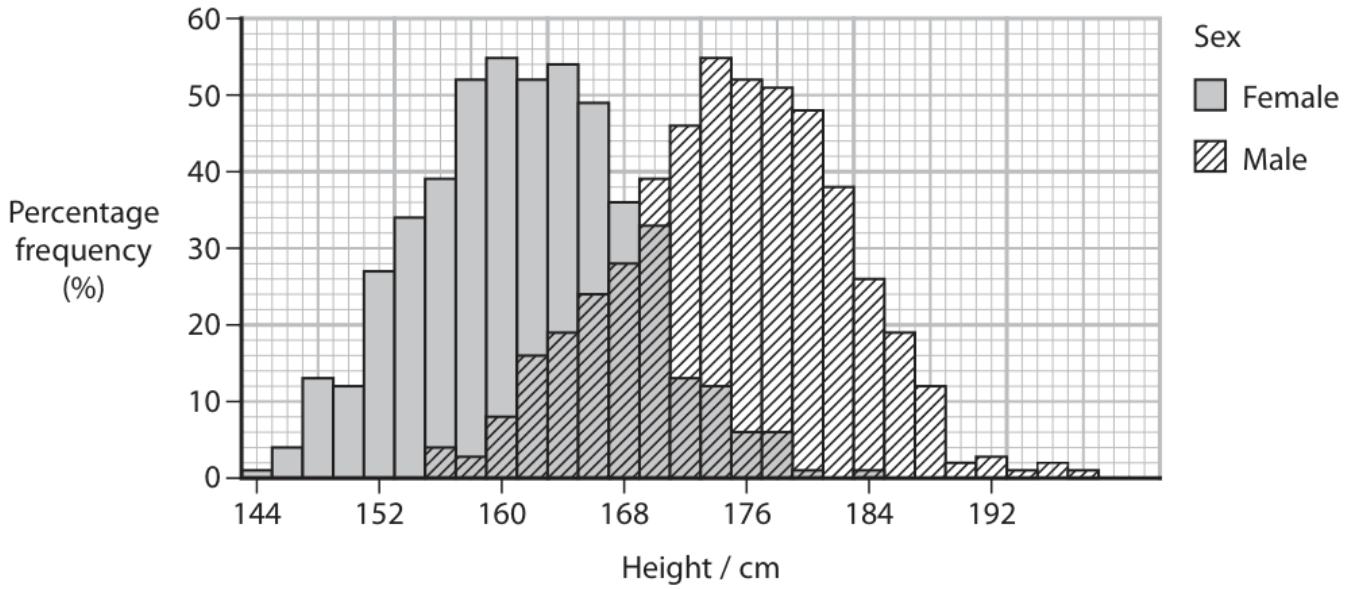
(3)

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Question 11 · information from earlier in the question

(c) Human height is another phenotype affected by polygenic inheritance.

The graph shows the frequency of height for two groups of adults.



Question 11 · AS Paper 2 · June 2023 · Q4(c)(ii) · 3 marks

(ii) The data show that there are more adults at the lower end of the range for height than at the higher end of the range for both females and males.

Explain how the interaction between environment and genotype can account for this difference.

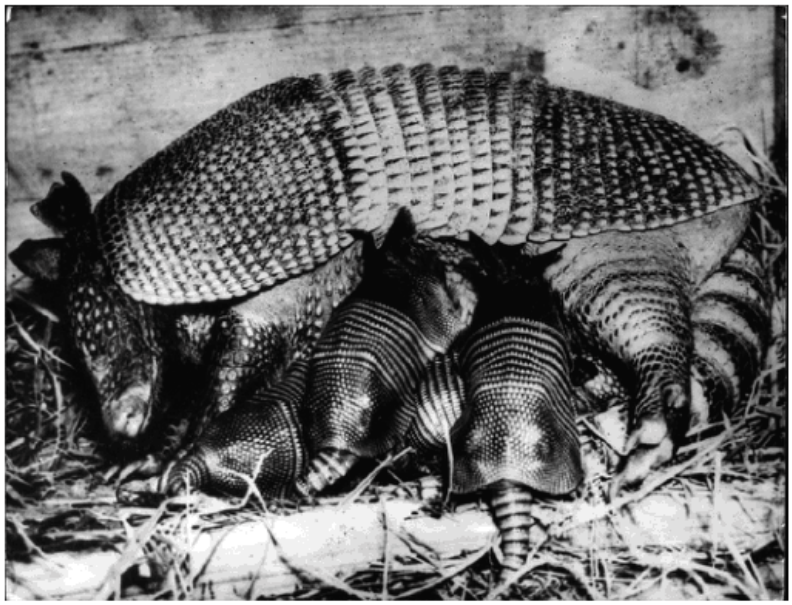
(3)

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Question 12 · information from earlier in the question

(b) An armadillo is a mammal that can produce litters of four genetically identical offspring.

The photograph shows an armadillo with a litter of four offspring.



(Source: © Keystone Press/Alamy Stock Photo)

Question 12 · AS Paper 2 · June 2025 · Q6(b)(ii) · 2 marks

(ii) Deduce why armadillos have been used to investigate the effects of the environment on phenotype.

(2)

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Question 13 · AS Paper 2 · June 2023 · Q5(a) · 3 marks

5 Smoking is an environmental factor that can cause lung cancer.

Smoking can cause epigenetic changes to the AHRR gene.

People who smoke cigarettes have less DNA methylation of this gene than non-smokers.

(a) Explain how DNA methylation can modify the activation of a gene.

(3)

Question 14 · information from earlier in the question

(b) The AHRR gene is involved in regulation of cell growth and differentiation.

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Question 14 · AS Paper 2 · June 2023 · Q5(b)(ii) · 3 marks

(ii) Deduce the reasons why reduced DNA methylation of the AHRR gene can increase the risk of lung cancer.

(3)

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(d) In mice, fur colour is determined by genetic and by epigenetic factors.

The photograph shows a litter of mice.



(Source: © Floris Slooff/Shutterstock)

All these mice

- have a gene that produces brown fur and this gene is always switched on
- have the agouti gene that can produce yellow fur.

In an investigation, female agouti mice with yellow fur were placed in two groups, A and B. The mice were fed different diets.

The table shows the features of their offspring.

Group	Diet	Features of offspring produced	
		Fur colour	Health
A	Rich in sources of methyl groups	Most had brown fur	Most had good health
B	Low in sources of methyl groups	Most had yellow fur	Most had poor health

(i) Deduce the effect of methyl groups in the diet on the features of the offspring of these mice.

(3)

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Question 16 · AS Paper 2 · June 2025 · Q6(d)(ii) · 2 marks

(ii) Epigenetic changes to the DNA of the offspring happen during their development inside the mother.

Explain how the results of this investigation support this statement.

(2)

Question 17 · A level Paper 1 · November 2021 · Q4(c) · 3 marks

(c) Factors such as the diet of the mother during pregnancy can cause epigenetic changes in the embryo.

Explain how epigenetic changes affect the development of tissues in the embryo.

(3)

Questions, mark schemes and examiners' report extracts © Pearson Education Ltd.

Question 18 · AS Paper 2 · June 2019 · Q1(b) · 4 marks

(b) Explain why an individual may have a greater adult height than their biological parents.

(4)

Question 19 · AS Paper 2 · November 2021 · Q5(b)(i) · 2 marks

(b) There are 2931 mutations to the F8 gene that have been identified.

Haemophilia can also be caused by a mutation to the F9 gene.
There are 1133 mutations to the F9 gene that have been identified.

Haemophilia is not classed as a polygenic disorder.

(i) Give the meaning of the term polygenic.

(2)

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Question 20 · AS Paper 2 · June 2025 · Q5(a)(ii) · 4 marks

(ii) Explain how **polygenic inheritance** can give rise to continuous variation in characteristics such as eye colour in humans.

(4)

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Mark schemes

Question 1 · AS Paper 2 · June 2016 · Q7(c) · 4 marks

Question Number	Answer
7(c)	An explanation that makes reference to four of the following: • (AFP II) { gene / allele } { activated only in liver cells / deactivated in cells other than liver cells } (1) • transcription (of AFP II) occurs only in liver cells (1) • { translation / protein synthesis } (of AFP II) takes place only in liver cells (1) • the protein is { secreted from liver cells / transported around the body } (1) • (presence of protein in all tissues) prevents { freezing / ice } in all parts of the body (1)

Additional Guidance	Mark
ALLOW "switched on/off" This deactivation could be due to DNA methylation / histone modification Ref to liver cells required only once if context / chain of argument is clear.	(4)

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Question 2 · AS Paper 2 · June 2017 · Q7(a)(ii) · 4 marks

Question Number	Answer
7(a)(ii)	A description that makes reference to the following: • different stimuli activate different genes **(1)** • genes activated are transcribed / mRNA produced from active genes **(1)** • mRNA translated to produce proteins **(1)** • proteins determine {structure / function} of cells **(1)** • different {genes activated / proteins produced} result in different types of cell being produced **(1)**

Additional Guidance	Mark
ALLOW switch on	**(4)**

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Question 3 · AS Paper 2 · June 2018 · Q2(c) · 3 marks

Question Number	Answer
2(c)	An explanation which makes reference to three of the following: • genes can be activated or deactivated (1) • (these cells) receive the same stimulus (1) • (all of these cells) have the gene for the enzyme { activated / switched on } (1) • resulting in production of mRNA for the enzyme (1)

Additional Guidance	Mark
ALLOW switched on or off	(3)

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Question 4 · AS Paper 2 · June 2023 · Q5(b)(i) · 4 marks

Question Number	Answer
5(b)(i)	An answer that makes reference to the following: • certain stimuli cause {some genes to be activated / some genes to be deactivated } (1) • (activated) genes are {transcribed / used to produce mRNA } (1) • (mRNA) translated to produce proteins (1) • (proteins) determine {structure/function} of cell (1)

Additional guidance	Mark
ALLOW polypeptide for protein	(4)

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Question 5 · A level Paper 2 · June 2019 · Q6(c)(i) · 3 marks

Question Number	Answer
6(c)(i)	An explanation that makes reference to three of the following: • presence of different stimuli (1) • (therefore resulting in) different genes being { activated / deactivated / transcribed / expressed } (1) • so different proteins are made (1) • proteins produced determine { structure / function } of cells (1)

Additional Guidance	Mark
e.g. transcription factors, chemical stimulus ALLOW different genes are switched {on / off} ALLOW 'tissues' for 'cells'	(3)

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Question 6 · A level Paper 2 · June 2022 · Q5(b)(ii) · 4 marks

5(b)(ii)	An explanation that makes reference to four of the following: • (by) differentiation (1) • (due to) certain stimuli (1) • (which causes) {some genes/ gene for haemoglobin} to be activated / some genes to be deactivated (1) • {mRNA / haemoglobin} produced from activated genes (1) • removal of nucleus / produce a biconcave shape (1)

ALLOW some genes switched on / switched off
IGNORE genes being turned on / off

(4)

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Question 7 · A level Paper 2 · June 2023 · Q2(b)(ii) · 3 marks

Question Number	Answer
2(b)(ii)	A description that makes reference to three of the following: • lactose allows the lac operon to function (1) • RNA polymerase can now bind to promoter (region) / repressor (molecule) no longer binds to operator (1) • allowing {transcription / mRNA to be synthesised} (1) • so enzymes involved in {metabolising / breaking down} lactose are made (1)

Additional Guidance	Mark
ALLOW lactose binds to repressor ALLOW lactase / (β) galactosidase produced	[3]

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Question 8 · A level Paper 3 · June 2023 · Q6(a) · 3 marks

Question number	Answer
6(a)	An explanation that makes reference to three of the following: • due to {chemical stimulus / transcription factors} (1) • activating specific genes (1) • resulting in synthesis of {proteins / enzymes} (1) • involved in the synthesis of melanin (1)

Additional guidance	Mark
ALLOW (causing) differential gene expression ALLOW some genes are {activated /switched on} and some are {deactivated / switched off} ALLOW translation of mRNA to produce protein	(3)

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Question 9 · A level Paper 1 · June 2025 · Q7(a)(ii) · 2 marks

Question Number	Answer
7(a)(ii)	A description that makes reference to two of the following: • a chemical {signal / stimulus} activates specific genes (1) • activated genes {transcribed / produce mRNA} (1) • this (mRNA) is translated to produce proteins which determine the {structure / function} of the cell (1)

Additional guidance	Mark
ALLOW reference to genes being deactivated ALLOW transcription factor for {chemical signal / stimulus}	(2)

Question 10 · A level Paper 2 · June 2018 · Q2(b) · 3 marks

Question Number	Answer
2(b)	An answer that makes reference to the following: • { FTO^T / saturated fat diet } is associated with increased BMI (1) • FTO^T (allele) is recessive / FTO^C (allele) is dominant (1) • highest increase in BMI was for individuals homozygous for FTO^T on a saturated fat diet (1)

Additional Guidance	Mark
ALLOW FTO^T FTO^T genotype	**(3)**

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Question 11 · AS Paper 2 · June 2023 · Q4(c)(ii) · 3 marks

Question Number	Answer
4(c)(ii)	An explanation that makes reference to three of the following: • not all fulfil genetic potential / not all achieve the height determined by their genotype (1) • due to dietary factor (1) • due to disease (1) • (dietary factor or disease occurring) during childhood (1)

Additional guidance	Mark
ALLOW genotype determines maximum possible height ALLOW example such as lack of {protein /calcium/ vitamin D} / malnutrition	(3)

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Question 12 · AS Paper 2 · June 2025 · Q6(b)(ii) · 2 marks

Question number	Answer
6(b)(ii)	An answer that makes reference to the following: • several individuals with the same genotype can be tested (1) • any differences between them when placed in different environments would be due to the environment and not to genotype (1)

Additional guidance	Mark
ALLOW genotype controlled IGNORE genetically identical offspring (repeating from the stem of the question) ALLOW any variation will be due to the environment	(2)

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Question 13 · AS Paper 2 · June 2023 · Q5(a) · 3 marks

Question Number	Answer
5(a)	An explanation that makes reference to three of the following: • methyl groups attached to DNA (1) • prevent transcription (of the gene) (1) • {transcription factors / RNA nucleotides} cannot bind to { DNA / promoter region of gene} (1) • {deactivating / switching off} a gene (1)

Additional guidance	Mark
ALLOW methyl group attached to {cytosine / CpG site} ALLOW { mRNA / RNA polymerase} cannot bind to {DNA/gene} ALLOW prevents activation of a gene	(3)

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Question 14 · AS Paper 2 · June 2023 · Q5(b)(ii) · 3 marks

Question Number	Answer
5(b)(ii)	An answer that makes reference to the following: • reduced DNA methylation results in activation of (AHRR) gene / DNA methylation prevents activation of the (AHRR) gene (1) • (reduced DNA methylation) results in { transcription of / production of mRNA from} (AHRR) gene (1) • increases cell division / cells (in the lung) may divide out of control (1)

Additional guidance	Mark
ALLOW DNA methylation {switches off / suppresses} (AHRR) gene ALLOW cell cycle goes through stages more rapidly ALLOW cells may become cancerous	Exp (3)

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Question 15 · AS Paper 2 · June 2025 · Q6(d)(i) · 3 marks

Question number	Answer
6(d)(i)	An answer that makes reference to three of the following: • those given diet high in methyl groups had brown fur / those given diet low in methyl groups had yellow fur (1) • (because) DNA methylation deactivates the agouti gene (1) • methylation of the agouti gene affects health (1) • health affected as diet low in methyl groups might alter the methylation of other genes (apart from the agouti gene) (1)

Additional guidance	Mark
ALLOW 'gene for yellow fur' instead of agouti gene ALLOW diet high in methyl groups deactivates agouti gene ALLOW agouti gene linked to poor health	(3)

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Question 16 · AS Paper 2 · June 2025 · Q6(d)(ii) · 2 marks

Question number	Answer
6(d)(ii)	An explanation that makes reference to two of the following: • (mother mice all had yellow fur and) the only difference was their diet (1) • the mothers given a diet low in methyl groups had offspring with yellow fur (1) • because the {agouti gene / gene for yellow fur} was activated (1)

Additional guidance	Mark
ALLOW diet high in methyl groups produced offspring with brown fur ALLOW agouti gene deactivated in offspring with brown fur	(2)

Question 17 · A level Paper 1 · November 2021 · Q4(c) · 3 marks

Question Number	Answer
4(c)	An explanation that makes reference to three of the following • DNA (in a chromosome) is wrapped around histones (1) • {acetylation / modification} of the histone affects {binding of RNA polymerase / chromosome unwinding} (1) • methylation of DNA affects { transcription of genes / production of mRNA } (1) • therefore gene expression is altered (1)

Additional guidance	Mark
ALLOW different proteins are synthesised	**(3)**

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Question 18 · AS Paper 2 · June 2019 · Q1(b) · 4 marks

Question Number	Answer
1(b)	An explanation that makes reference to the following • height is affected by the environment as well as genotype (1) • height is an example of polygenic inheritance (1) • (therefore) offspring can inherit a mixture of alleles from both parents (that increase height) (1) • description of a named environmental factor that can affect height (1)

Additional Guidance	Mark
e.g. higher protein diet, more calcium in diet, better healthcare ALLOW parents did not fulfil genetic potential due to a named environmental factor	(4)

Question 19 · AS Paper 2 · November 2021 · Q5(b)(i) · 2 marks

Question Number	Answer	Additional guidance	Mark
5(b)(i)	A description that makes reference to the following: • a characteristic showing continuous variation (1) • caused by multiple genes at different loci (1)		(2)

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Question 20 · AS Paper 2 · June 2025 · Q5(a)(ii) · 4 marks

Question number	Answer
5(a)(ii)	An explanation that makes reference to four of the following: • many genes involved (1) • at different loci (1) • each having a small effect on the phenotype (1) • therefore having a cumulative effect (1) • therefore causing a range within the characteristic (1)

Additional guidance	Mark
ALLOW more than one gene involved ALLOW description of a cumulative effect ALLOW example such as eye colour there is a range from pale blue to dark brown	(4)

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