Inheritance (2.5): Eduqas A Level Biology Exam Questions by Topic

24 questions · 58 marks · about 70 minutes. Answer in the spaces, then check the mark schemes at the end.

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One sub-species is polymorphic. The undersides of the three forms of the sub-species found on the islands are shown in Figure 4.1.

Figure 4.1



chestnut | chestnut-black | black

(b) In breeding experiments:

- chestnut crossed with black always produced chestnut-black offspring,
- chestnut-black crossed with other chestnut-black produced offspring of all three phenotypes.

Using appropriate symbols, complete the key to identify the alleles involved.
Use these symbols to complete the genetic diagram below to show a cross between two chestnut-black parents and predict the phenotype ratio of the offspring. [4]

Key: Allele for Chestnut colour ..... Allele for Black colour .....

Parental phenotypes:	chestnut-black	x	chestnut-black
Parental genotypes:	.....	x	.....
Gametes:	.....	x	.....

F_1 Genotypes ....

F_1 Phenotypes ....

Phenotype ratio .....

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Question 2 · information from earlier in the question

(b) The ABO blood groups are determined by a single gene with three different alleles.

Allele I^A codes for enzyme **A**.

Allele I^B codes for enzyme **B**.

Allele I^O does not code for either enzyme.

Alleles $\mathbf{I^A}$ and $\mathbf{I^B}$ are codominant and $\mathbf{I^O}$ is recessive to both.

Question 2 · A level Component 2 · June 2025 · Q5(b)(ii) · 2 marks

(ii) A child with blood group O was born to parents with blood groups A and B.

Complete the genetic diagram below to show a cross between these parents that could produce a child with blood group O. [2]

Parental phenotypes	Blood Group A	Blood Group B
Parental genotypes	.....	.....
Genotypes of gametes	.....	.....

Genetic diagram

Genotypes of children ....

Question 3 · A level Component 2 · June 2025 · Q5(b)(iii) · 1 mark

(iii) State the probability that another child born to these parents will have blood group O. [1]

.....

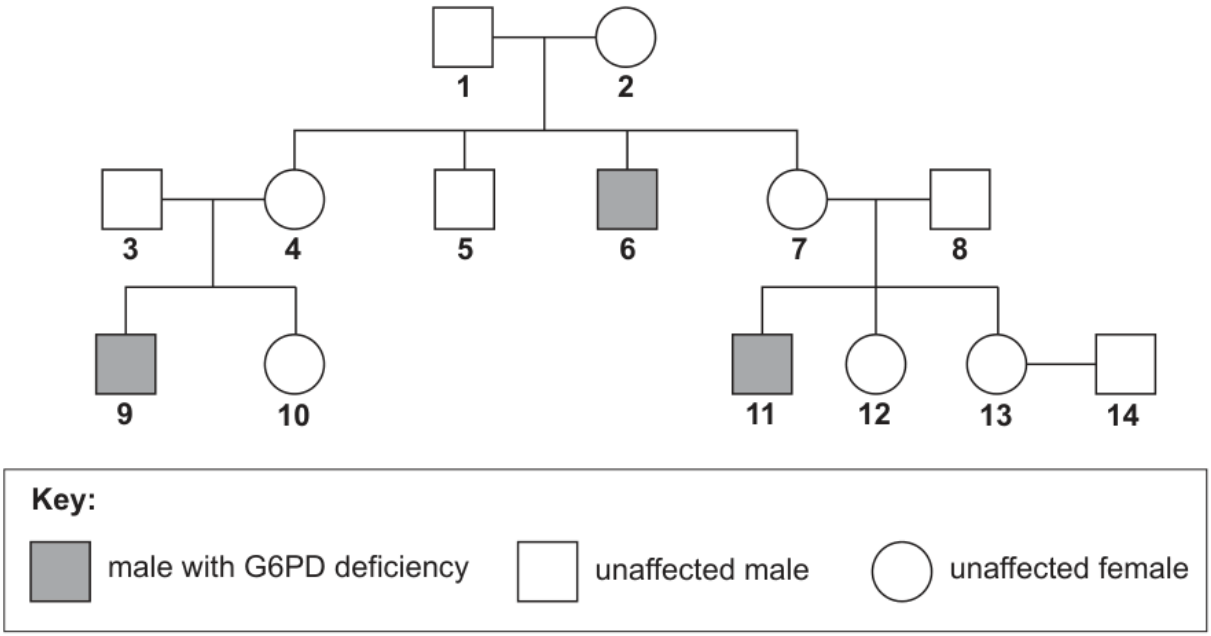
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Question 4 · information from earlier in the question

(b) G6PD deficiency is a hereditary condition in which red blood cells break down when the body is exposed to certain foods, drugs, infections or stress. The gene coding for G6PD is found on the X chromosome.

Image 3 shows the inheritance of G6PD deficiency in one family.

Image 3



Question 4 · A level Component 2 · June 2024 · Q3(b)(ii) · 2 marks

(ii) G6PD deficiency is caused by a recessive allele.
Explain this statement. Use a suitable example from **Image 3** to support your answer. [2]

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.....

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Question 5 · information from earlier in the question

(c) In one experiment, Mendel crossed pure breeding pea plants which produced smooth, yellow peas with pure breeding plants that produced wrinkled, green peas. The F_1 were allowed to self-fertilise. **Image 1.1** shows the F_1 and F_2 offspring produced in this experiment.

Image 1.1

Parent traits: smooth, yellow × wrinkled, green

F_1 trait all smooth yellow

F_2 traits

		Seed colour		
		yellow	**green**	**total**
Seed shape	**smooth**	311	106	417
	wrinkled	101	33	134
	total	412	139	551

Question 5 · A level Component 2 · Autumn 2020 · Q1(d)(i) · 1 mark

(d) In the early 1900s, further genetic crosses were carried out to investigate inheritance in the garden pea. They studied two characters, flower colour – purple or red, and the shape of pollen grains – long or round. They crossed plants that were pure breeding for purple flowers and long pollen grains with plants pure breeding for red flowers and round pollen grains. The F_1 were allowed to self-fertilise to produce the F_2 generation. The results of this cross are shown in **table 1.2**.

Table 1.2

Characteristics	Number of offspring
purple flower, long pollen grains	4 831
purple flower, round pollen grains	390
red flower, long pollen grains	393
red flower, round pollen grains	1 338

(i) Suggest why this cross did not produce the same ratio of the combination of characters as found by Mendel in his experiment. [1]

.....

.....

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Question 6 · A level Component 2 · Autumn 2021 · Q5(a)(ii) · 2 marks

(ii) State what is meant by the term *linkage* and explain why Mendel's law of independent assortment only applies if the genes are not linked. [2]

.....

.....

.....

.....

Question 7 · A level Component 2 · June 2017 · Q4(a)(i) · 4 marks

4. In mice, coat colour is determined by genes at more than one locus.

Locus I.
This gene determines the colour of pigment. There are two major alleles: **B** coding for black pigment and **b** for brown.

Locus II.
This gene determines the distribution of pigment in the hair. Allele **A** produces a phenotype called agouti. The agouti phenotype is due to yellow bands on the otherwise dark hair shaft. In the non-agouti phenotype (determined by the allele **a**), the yellow bands are absent, so the hair shaft is a solid dark colour.

The table below shows the genotypes and corresponding phenotypes.

Locus I genotype	Locus II genotype	Phenotype (coat colour)
BB or Bb	**AA or Aa**	Normal agouti
BB or Bb	**aa**	Solid black
bb	**AA or Aa**	Cinnamon (brown with yellow bands)
bb	**aa**	Solid brown

(a) (i) Complete the genetic diagram below to show the expected outcome of crossing mice heterozygous at both loci. [4]

Parental phenotype ..... x .....

Parental genotype ..... x .....

Gametes ..... x .....

Question 8 · A level Component 2 · June 2017 · Q4(a)(ii) · 1 mark

(ii) Give the ratio in which the following phenotypes would appear in the offspring. [1]

Offspring phenotypes: normal agouti : solid black : cinnamon : solid brown

Phenotype ratio: ..... : ..... : ..... : .....

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Question 9 · A level Component 2 · June 2017 · Q4(b)(i) · 3 marks

A series of crosses between mice which were heterozygous at both loci produced 32 offspring. The results are shown in the table below. A null hypothesis was proposed that there was *'no significant difference between the observed and expected numbers of offspring'*.

Phenotype	Observed *O*	Expected *E*		
Normal Agouti	22			
Solid black	4			
Cinnamon	3			
Solid brown	3			

(b) (i) Using the table provided, calculate χ^2 to test this null hypothesis. [3]

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

χ^2 = ...

Question 10 · A level Component 2 · June 2017 · Q4(b)(ii) · 1 mark

(ii) Choose an appropriate probability level and circle the critical value for χ^2 in the table below: [1]

Degrees of freedom	Probability								
	0.9	0.8	0.7	0.5	0.2	0.1	0.05	0.02	0.01
1	0.016	0.064	0.15	0.46	1.64	2.71	3.84	5.41	6.64
2	0.21	0.45	0.71	1.39	3.22	4.60	5.99	7.82	9.21
3	0.58	1.00	1.42	2.37	4.64	6.25	7.82	9.84	11.34
4	1.06	1.65	2.20	3.36	5.99	7.78	9.49	11.67	13.28

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Question 11 · A level Component 2 · June 2017 · Q4(b)(iii) · 2 marks

(iii) State whether you accept or reject the null hypothesis, and explain why. [2]

.....

.....

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(b) Pollen from the F1 generation was transferred to the stigma of pure-bred plants with rough striped leaves. The expected ratio of the phenotypes of the offspring from this cross is 1:1:1:1.

Seeds from this cross were grown and the following phenotypes were seen.

Glossy green leaves	64
Glossy striped leaves	12
Rough green leaves	11
Rough striped leaves	73

A null hypothesis was proposed that there was 'no significant difference between the observed and expected numbers of each phenotype in the offspring'.

A χ^2 (chi-squared) test can be carried out to find the probability of the results being significantly different from the expected ratio.

The χ^2 calculation is shown below.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Where O = observed results
E = expected results
$\sum$ = sum of

(i) Use the information given to complete **Table 6.1** and calculate χ^2 for these results. [3]

Table 6.1

Phenotype	Observed number (O)	Expected number (E)	$O-E$	$(O-E)^2$	$\frac{(O-E)^2}{E}$
Glossy green leaves	64	.....	.....	.....	.....
Glossy striped leaves	12	.....	.....	.....	.....
Rough green leaves	11	.....	.....	.....	.....
Rough striped leaves	73	.....	.....	.....	.....

χ^2 = ...

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Question 13 · information from earlier in the question

Table 6.2

Degrees of freedom	Probability								
	0.9	0.8	0.7	0.5	0.2	0.1	0.05	0.02	0.01
1	0.016	0.064	0.15	0.46	1.64	2.71	3.84	5.41	6.64
2	0.21	0.45	0.71	1.39	3.22	4.60	5.99	7.82	9.21
3	0.58	1.00	1.42	2.37	4.64	6.25	7.82	9.84	11.34
4	1.06	1.65	2.20	3.36	5.99	7.78	9.49	11.67	13.28

Question 13 · A level Component 2 · June 2023 · Q6(b)(iv) · 2 marks

(iv) State what conclusion can be made from these results and explain your answer. [2]

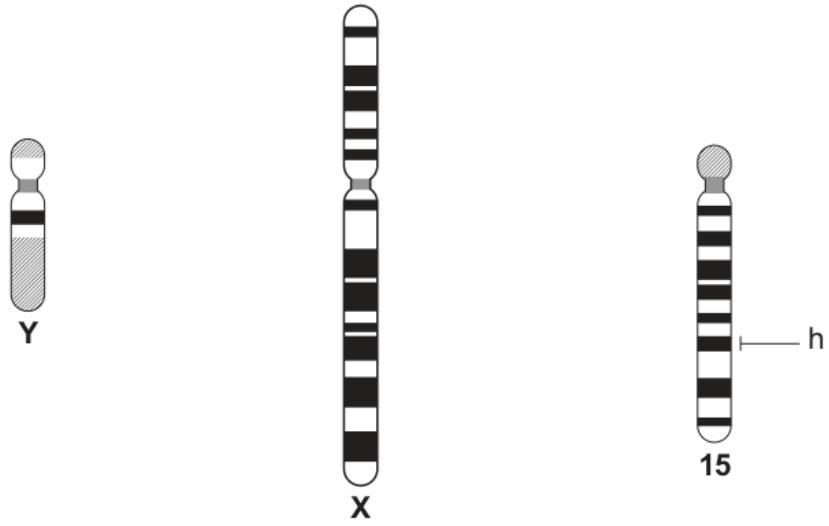
Question 14 · A level Component 2 · June 2023 · Q6(b)(v) · 4 marks

(v) With reference to the results of the cross, explain why the actual ratio of phenotypes obtained was different from the expected ratio. [4]

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Question 15 · information from earlier in the question

(c) The diagrams below show gene maps of human sex chromosomes and chromosome **15**. The recessive allele **(f)** that causes Fabry disease is carried on the **X** chromosome. The recessive allele **(h)** that causes Tay-Sachs is carried on chromosome **15**, in the locus labelled h.



Question 15 · A level Component 2 · June 2018 · Q1(d) · 4 marks

(d) Complete the genetic diagram below to show how Fabry disease might be inherited from parents neither of whom suffers from the condition and state the probability of this couple producing a child with Fabry disease. [4]

	male		female
Parental phenotype:	.....		.....
Parental genotypes:	.....	x	.....
Gametes:	.....	x	.....

Probability of this couple producing a child with Fabry disease = ...

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Question 16 · A level Component 2 · June 2022 · Q6(c)(i) · 1 mark

(c) Cats can suffer from a muscle wasting disease similar to muscular dystrophy in humans and have been used as an animal model for human muscular dystrophy.

To investigate the inheritance of muscular dystrophy in cats, a breeding colony was established from a single affected male. The 1st generation (F_1) was obtained through breeding the original affected male with two unaffected female cats. The F_1 females were then bred back to their father to obtain the F_2 generation.

Table 6.3 shows the number of normal and affected male and female cats in the F_1 and F_2 generations.

Table 6.3

Phenotype	Number of cats	
	F_1 generation	F_2 generation
Female normal	7	8
Female affected	0	5
Male normal	6	7
Male affected	0	5

Based on these results it was concluded that cat muscular dystrophy is inherited as an X-linked recessive condition.

(i) State what is meant by an X-linked condition. [1]

.....

.....

Question 17 · A level Component 2 · June 2022 · Q6(c)(ii) · 4 marks

(ii) There are three possible gametes that can be produced by the male and female cats: $\mathbf{X^D}$, $\mathbf{X^d}$, and **Y**, where **D** = unaffected and **d** = muscular dystrophy. Complete the genetic diagram below to show how female cats with muscular dystrophy were produced in the F_2 generation. [4]

Parental phenotype ..... × .....

Parental genotype ..... × .....

Gametes ..... × .....

Genotype of female cat with muscular dystrophy .....

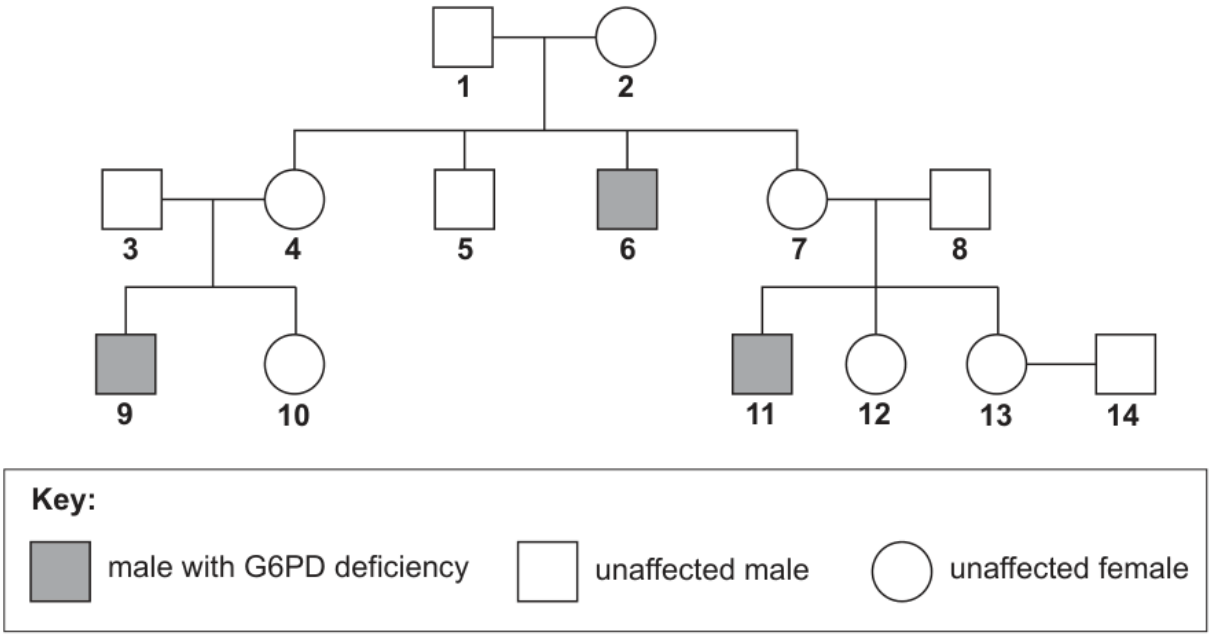
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Question 18 · information from earlier in the question

(b) G6PD deficiency is a hereditary condition in which red blood cells break down when the body is exposed to certain foods, drugs, infections or stress. The gene coding for G6PD is found on the X chromosome.

Image 3 shows the inheritance of G6PD deficiency in one family.

Image 3



The following symbols represent the chromosomes and alleles carried by individuals in **Image 3**.

X^G = an X chromosome carrying the unaffected allele
X^g = an X chromosome carrying the allele for G6PD deficiency
Y = a Y chromosome

Question 18 · A level Component 2 · June 2024 · Q3(b)(iv) · 1 mark

(iv) A genetic screening test shows that individual **13** is a carrier of the allele for the G6PD deficiency.

Determine the probability that a child of individuals **13** and **14** will be a male with G6PD deficiency. [1]

Probability = ...

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Question 19 · A level Component 2 · June 2025 · Q5(d)(iii) · 3 marks

Some mutations occur when one nucleotide is substituted by a different nucleotide in a strand of DNA.

(iii) Explain how the substitution of a nucleotide may cause a gene to code for a different protein. [3]

Question 20 · A level Component 2 · June 2019 · Q4(e) · 2 marks

(e) Since the 1950s, nuclear weapons tests have taken place in the South Pacific. Suggest how this might have accounted for the emergence of the black phenotype on the Solomon Islands. [2]

Question 21 · A level Component 2 · Autumn 2020 · Q2(d)(i) · 2 marks

(d) Mutations that occur during DNA replication can be responsible for causing cells to become cancerous by activating genes that prevent the control of cell division. However, cancerous growths (tumours) are very rare in *C. elegans* and only occur in the germ line cells.

(i) Name the genes that when mutated can trigger uncontrolled cell division and state the term used to describe the chemicals that can cause these mutations. [2]

Genes .....

Term used to describe chemicals .....

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Question 22 · A level Component 2 · Autumn 2020 · Q2(e) · 3 marks

(e) Scientists have used *C. elegans* to study epigenetic effects on genes that are involved in the control of the cell cycle and how these effects could trigger the development of cancers.

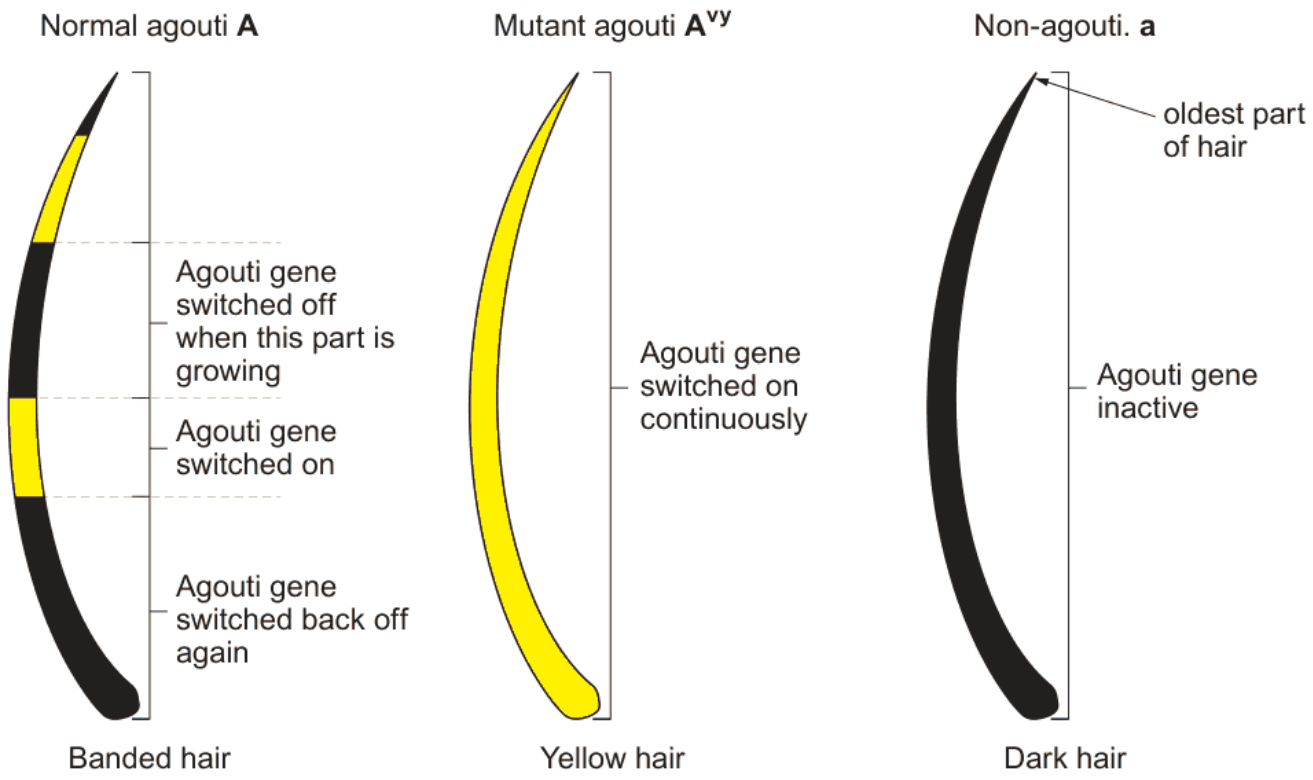
One form of epigenetic modification involves the methylation of cytosine bases in regions of genes that control the expression of that gene.

Explain how methylation could affect the quantity of a polypeptide produced, but not the structure of a polypeptide. [3]

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Question 23 · information from earlier in the question

A mutant form of the gene at locus II exists, called $\mathbf{A^{vy}}$, which results in hair which is yellow along its entire length. The diagrams of hairs below explain how each of the locus II alleles works.



Scientists have bred a strain of mice with the genotype $\mathbf{A^{vy}a}$.

Since $\mathbf{A^{vy}}$ is dominant to **a**, all of the mice with genotype $\mathbf{A^{vy}a}$ could be expected to be yellow.

In fact, some are yellow, some are normal agouti and some are shades in between.



These mice have identical DNA base sequences in the agouti gene locus but the gene is being expressed differently.

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Allele ***A*** codes for the synthesis of a protein which switches off the gene in a cyclic manner.
The mutation in A^{vy} is an insertion of a sequence of bases which forms abnormal RNA molecules which block the formation of the normal RNA.

Question 23 · A level Component 2 · June 2017 · Q4(c)(iii) · 3 marks

The addition of methyl groups to DNA molecules (methylation) is known to interfere with the ability of the molecules to take part in the formation of mRNA.
It has been suggested that methylation of the inserted sequence of bases could be responsible for the range of colours seen in the mice with genotype $\mathbf{A^{vy}a}$.

(iii) Explain how the addition of an increasing number of methyl groups to the inserted sequence of bases results in mice with a range of coat colours. [3]

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Question 24 · A level Component 2 · June 2024 · Q4(c) · 3 marks

(c) A group of scientists recently studied the genomes of the two forms of fish.

The scientists found the two forms of fish had very similar genomes but there were much higher levels of methylation in the **cave form** when compared with the **surface form**.

Methylation is the addition of methyl groups to bases.

Suggest what these findings may show about the effect of the levels of methylation present in the DNA of the **cave form**. Explain your answer. [3]

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Mark schemes

Question 1 · A level Component 2 · June 2019 · Q4(b) · 4 marks

(b)	Genotypes (1) RB × RB any suitable letters but must be <u>capitals</u>; Correct gametes (1) ECF F_1 genotypes (1) ECF Ratio: 1 (chestnut) : 2 (chestnut-black) : 1 (black) ECF		4	4	1

Question 2 · A level Component 2 · June 2025 · Q5(b)(ii) · 2 marks

	(ii)	Genotype parents, $I^A I^O$ $I^B I^O$ (1) Genotypes children, $I^A I^O$ $I^A I^B$ $I^O I^O$ $I^B I^O$ (1)	2	2	

Question 3 · A level Component 2 · June 2025 · Q5(b)(iii) · 1 mark

	(iii)	0.25/ ¼ /1 in 4/ 25% Reject ratios	1	1	

Question 4 · A level Component 2 · June 2024 · Q3(b)(ii) · 2 marks

		(ii)		{Parents without deficiency / carriers / mothers } have {offspring / sons} with deficiency / owtte} (1) Example : (1 and 2) produce 6 / (3 and 4) produce 9 / (7 and 8) produce 11 (1)	2		2	

Question 5 · A level Component 2 · Autumn 2020 · Q1(d)(i) · 1 mark

(d)	(i)	linkage / on same chromosome (1)	1	1	

Question 6 · A level Component 2 · Autumn 2021 · Q5(a)(ii) · 2 marks

(ii)	(Linkage =) genes present on same chromosome (1) (if on same chromosome) {more likely to be segregated together / cannot be segregated independently} / can only segregate independently if on different chromosomes (1)	2	2

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Question 7 · A level Component 2 · June 2017 · Q4(a)(i) · 4 marks

4	(a)	(i)	Phenotype: (Normal) agouti x (normal) agouti (1)NOT black Genotype: AaBb (1) AB Ab aB ab (1) correct completion of punnet square (1)		4	4	

Question 8 · A level Component 2 · June 2017 · Q4(a)(ii) · 1 mark

(ii)	All phenotypes from the table in the ratio 9:3:3:1		1	1	1	

Question 9 · A level Component 2 · June 2017 · Q4(b)(i) · 3 marks

(b)	(i)		Correct values of E 18, 6, 6, 2 (1) $(O-E)^2/E$ 0.89, 0.67, 1.5, 0.5(1) ECF Correct value of χ^2 = 3.56 (1)ECF		3	3	3	3

Question 10 · A level Component 2 · June 2017 · Q4(b)(ii) · 1 mark

(ii)		7.82 circled		1	1	

Question 11 · A level Component 2 · June 2017 · Q4(b)(iii) · 2 marks

(iii)		Accept (1) ecf because calculated value of χ^2 is less than critical value/ probability is greater than 0.05 (1)			2	2	

Question 12 · A level Component 2 · June 2023 · Q6(b)(i) · 3 marks

(b) (i)

Phenotype	Observed number (O)	Expected number (E)	O-E	$(O-E)^2$	$(O-E)^2/E$
Glossy, green leaves	64	40	24	576	14.4
Glossy, green and white striped leaves	12	40	-28	784	19.6
Rough, green leaves	11	40	-29	841	21.03
Rough, green and white striped leaves	73	40	33	1089	27.23

3 3 3 3

χ^2 = Accept 82.25 or 82.26 = 3 marks
Award 2 marks for
82.2 or 82.3
If incorrect award 1 mark for each of
expected number = 40
correct $(O-E)^2/E$ column

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Question 13 · A level Component 2 · June 2023 · Q6(b)(iv) · 2 marks

(iv)	There is a significant difference between the observed and expected {numbers /results}/ Results are not due to chance (1) Null hypothesis should be rejected (1)	2	2

Question 14 · A level Component 2 · June 2023 · Q6(b)(v) · 4 marks

(v)	**Any four (x 1) from:** A. The genes are {linked /on the same chromosome} / autosomal linkage (1) B. {Large number/ more} of {non-recombinants/ glossy green **and** rough striped}/ owtte (1) C. {Small number/ less} of {recombinants/ glossy striped **and** rough green}/ owtte (1) D. From crossing over {in meiosis 1/prophase 1} (1) E. Between homologous chromosomes (1)	4	4

Question 15 · A level Component 2 · June 2018 · Q1(d) · 4 marks

(d)		X^FY $X^F X^f$ (1)  accept alternative convention correct gametes (1) correct completion of punnet square/outcomes (1) 0.25/25%/¼ ecf (1) Accept 3:1 or 1:3 if unambiguous		3	1 4	2

Question 16 · A level Component 2 · June 2022 · Q6(c)(i) · 1 mark

(c)	(i)	(Carried on) X-chromosome (1) 1		1	

Question 17 · A level Component 2 · June 2022 · Q6(c)(ii) · 4 marks

(ii)	Parent phenotypes (either order but phenotype and gametes must then match): Carrier / unaffected / normal + female **and** affected + male (1) Parent genotypes: (1) X^DX^d X^dY Gametes: (1) X^D, X^d X^d, Y Correct female cat genotype X^dX^d (1)	4	4		

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Question 18 · A level Component 2 · June 2024 · Q3(b)(iv) · 1 mark

(iv)		1 in 4 / 25% / 0.25 / ¼ NOT 1:4	1	1	1

Question 19 · A level Component 2 · June 2025 · Q5(d)(iii) · 3 marks

	(iii)	**Any three (x1) from** A. Base {sequence / order} is changed (1) B. Different (sequence of bases in) {mRNA / codon} / or example of (1) C. {Attracts / owtte} different {tRNA / anticodon} (1) D. different amino acid (sequence / inserted / coded for) / may produce different length protein (if mutation codes for a stop codon) (1)		3	3

Question 20 · A level Component 2 · June 2019 · Q4(e) · 2 marks

	(e)		Radiation (from nuclear weapons) (1) acts as a mutagen/ causing a mutation / increased rate of mutation/ or description of (1)	2	2	

Question 21 · A level Component 2 · Autumn 2020 · Q2(d)(i) · 2 marks

	(d)	(i)	proto-oncogenes / oncogenes (1) mutagens/ carcinogens (1)	2	2

Question 22 · A level Component 2 · Autumn 2020 · Q2(e) · 3 marks

	(e)			modification does not affect the base sequence of the gene (1) transcription is {affected / reduced}/ gene not expressed (1) translation produces same amino acid sequence (1)		3		3		

Question 23 · A level Component 2 · June 2017 · Q4(c)(iii) · 3 marks

(iii)	Methylation makes DNA tighter/more tightly would (around histones) The more methylation the {less blocking molecule (abnormalRNA) / more regulator protein} is made (1) The more the gene is switched on and off (1)NOT in different places The more methylation the {more agouti the colour/ the more banding/less yellow} (1)		3	3

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Question 24 · A level Component 2 · June 2024 · Q4(c) · 3 marks

	(c)		• (Increased methylation leads) to {non-production of eyes / blindness} (1) • Switches genes off / genes not expressed / or description of effect of methylation / {prevents / less} transcription (which are needed to produce eyes) (1) • epigenetic (factor) (1)	1 2 3

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