Mark schemes

1

Parental genotypes: Gg nn gg Nn ;

Gamete genotypes Gn gn gN gn ;

	gN	gn
Gn	Gg Nn Grey, normal	Gg nn Grey, vestigial
gn	gg Nn Ebony, normal	gg nn Ebony, vestigial

All offspring genotypes correct;

All offspring genotypes correctly derived;

[4]

2

(a) (i) Only seen in males / not in females;

1

(ii) Unaffected parents / mother → child with M.D. /
(1 ×)2 → 5 / (3 ×) 4 → 11 / 8 (× 9) → 13;

1

(b) 5 = X^dY

6 = X^DY

7 = X^DX^d AND X^DX^D

8 = X^DX^d;;

All 4 correct = 2 marks

2 or 3 correct = 1 mark

max 2

(c) ¼ / 0.25 / 25% / 1:3 / 1 in 4; (*NOT* '1:4')

1

[5]

3

(a) Cannot make (active) enzyme A (which converts precursor to linamarin) / cannot make linama

r
i
n
;
1

(b) (i) **AL** + **Al** + **aL** + **al** ;

1

(ii) Meiosis separates alleles / homologous chromosomes / pairs of chromosomes;
Independent assortment / means either of **A** / **a** can go with either of **L** / **l**;

[Accept: 'random segregation'] [Cancel: if reference to crossing-over]

2

(d) From parental genotypes: **AaLl** × **AaLl** (no mark)

[Note: If wrong parental genotypes / wrong gametes: ALLOW correct derivation of offspring genotypes] (= max 1)

Correct derivation of offspring genotypes:

	AL	**Al**	**aL**	**al**
AL	AALL	AALl	AaLL	AaLl
Al	AALl	AAll	AaLl	Aall
aL	AaLL	AaLl	aaLL	aaLl
al	AaLl	Aall	aaLl	aall

;

Correct identification of offspring genotypes with at least one **A** and two **l** alleles (= grey cells in above table);
Correct proportion: 3 / 16 / 3:13 / 18.75% ;

3

(e) (i) There was no (significant) difference in damage between cyanogenic andacyanogenic / being cyanogenic has no effect;

1

(ii) The difference (from expected / from chance variation) is significant / difference / results not just due to chance;
Reject null hypothesis;
Being cyanogenic does help protect from slug damage;

3

(f) High slug population:
1. Find <u>only</u> cyanogenic plants / only cyanogenic plants survive;
2. (Cyanide release) limits / stops feeding by slugs / slugs killed;

[Accept: converse argument re. acyanogenic plants]

Low slug population:

3. Find both types of plant;
4. Less selection pressure from slugs / no selective advantage / no selection /described;

4

[15] (a) Gg / suitable equivalent;

4

Grey : black about 3: 1;

[Note: Can be in table / diagram]

2

(b) To determine the probability;

[Accept: Likelihood]

Of the results being due to chance;

[Accept: Coincidence]

2

(c) (i) both alleles will be expressed (in the phenotype);

1

(ii) 0.25 / 25%; = 2 marks

C^N = 250 / 1000; = 1 mark

2

(iii) P^2 = $(0.25)^2$ / 0.0625 / square of calculated figure for C^N; = 2 marks $p^2 + 2pq + q^2$ = 1.0; = 1 mark

= 31.25 / 31;

[Accept: Derived from either p^2 or q^2]

3

[10]

(a) Only expressed in the homozygote / not expressed in the heterozygote / not expressed if

5 dominant present;

1

(b) Tt Aa × tt aa ;

TA Ta tA ta ta ;

	TA	Ta	tA	ta
ta	TtAa	Ttaa	ttAa	ttaa
	Orange striped	Orange unstriped	White striped	White unstriped / snowy

;

;

If parental genotype incorrect allow 1 mark for correct gametes based on given genotype and 1 mark for correct cross based on these gametes = 2 max <u>MUST</u> be clear link between F1 genotype and phenotype.

4

(c) (White) not camouflaged / not got stripes / white colour stands out;

Prey can take avoidance or are aware earlier / sooner;

Must have a time reference

2 max

[7] (a) (i) BBX^AY, BbX^AY;

6

1

(ii) BbX^AX^a, bbX^AX^a;

1

(b) *parental genotypes* − BbX^AY x $BbX^A X^a$;

1

Gametes − (BX^A, bX^A,) BY, bY, BX^A, B X^a, bX^A, b X^a ;

1

Genotypes of sons- ;

		Male gametes	
		BY	bY
Female gametes	BX^A	BBX^AY	BbX^AY
	B X^a	BB X^a Y	Bb X^a Y
	bX^A	BbX^AY	bbX^AY
	b X^a	Bb X^a Y	bb X^a Y

1

0.125 / 12.5% / 1/8 ;

1

[6] (a) aabb;

7

1

(b) AaBb and aabb;

1

(c) Pea comb offspring will produce blue eggs;

Alleles **A** and **B** are inherited together / are on the same chromosome;

2

(d) Reference to crossing over;
Reduce chance of genes being separated (by crossing over);
If crossing over occurred some gametes will contain alleles **A** and **b**;

2 max

(e) Two suitable environmental factors;

e.g.
Diet / named component of diet;
Temperature;
Light intensity / duration;
Disease;

2 max

(f) Cross C / X^f X^f and X^FY;

1

(Only) cross where all males are one phenotype and all females are a different phenotype;
Cross showing all males are slow feather production, all females fast feather production;

2

(g) Two alleles for each gene present in male / chromosomes are homologous in male;
Female has one allele for each gene;
Recessive alleles always expressed in female;
Males need two recessive alleles for allele to be expressed / in males recessive alleles can be masked by dominant allele

3 max

[14]

8 (a) hhDD, hhDd;

(both correct 1 mark)

1

(b) Epistasis;
One gene controlling / inhibiting the expression of another;

2

(c) Gametes correct HD, Hd, hD, hd, hd
(*correct for both parents)*;

Genotypes HhDd, Hhdd, hhDd, hhdd ;

Phenotypes wiry wiry non-wiry, short non-wiry, long

Ratio 2 1 1 ;

3 **[6]**

9

(a) *Two linked points:*

Crossing over / exchange of material (between chromatids);
Different combinations of alleles / linkage groups changed / broken;

OR

Independent assortment / alignment of (homologous) chromosomes;
Different combinations of (maternal and paternal) chromosomes / alleles;

2 max

(b)

Gamete genotype $\frac{D}{M}$ $\frac{d}{m}$;

Offspring genotype $\frac{D}{M}$ $\frac{d}{m}$;

Offspring Abnormal males / (all) (no females); phenotypes

3

[5] (a) (i) black;

10

1

(ii) chocolate;

1

(b) **BE**, **Be**, **bE**, **be** and **be**;
BbEe, Bbee, bbee, bbEe;
1 black: 2 yellow: 1 chocolate;

3

(c) (i) no enzyme coded for when no dominant / **E** allele;
phaeomelanin not converted – (remains yellow);

2

(ii) **E** allele results in enzyme producing eumelanin;
B allele - more eumelanin deposited in hairs;

2

[9] (a) males are XY and females XX / males have one X chromosome and females two X

11 chromosomes;

males only have one allele (of the gene) present / recessive allele always expressed;
colour blindness is masked in heterozygote / female needs 2 recessive alleles to be colour blind;

2 max

(b) (i) 5 - hh X^b Y;
6 - Hh X^B X^b ;

2

(ii) h X^b , h Y, and H X^B, h X^B, H X^b , hX^b;

1

(iii) 1 / 8 or 12.5% or 0.125;;

either genetic diagram to show genotypes Hh X^b X^b , Hh X^BY, hh X^B X^b, hh X^BY, HH$X^b$$X^b$, Hh X^bY, hh X^b X^b; hh X^bY;
1 / 8;
or
P (boy) = 0.5, P (colour blind) = 0.5, P (white streak) = 0.5;
(0.5 × 0.5 × 0.5 =) 0.125;

2

[7] (a) is always expressed(in the phenotype) / produces (functional) proteins;

12

1

(b) codominance;

1

(c) *Parental geneotypes* - hhC^{R}C^{w} , HhC^{w}C^{w} ;

Gametes- hC^{R} hC^{w} HC^{w} hC^{w}

Offspring geneotypes - HhC^{R}C^{w} , hhC^{R}C^{w} , HhC^{w}C^{w} , hhC^{w}C^{w} ;
Offspring pheneotypes - hornless horned hornless horned roan roan white white
Ratio of offspring - 1 1 1 1;

4

(d) (i) sperm(with more DNA) have X chromosome;
X is larger / has more genes than Y;

2

(ii) female for milk / males for meat / male or female for breeding;

1

[9] (i) female XX, male XY;

13

Y <u>shorter / smaller</u> than X;

2

(ii) haemophilia is a recessive allele; defective allele (gene) present on X, missing from Y; male 0.5(50%

/ ½) probability of haemophilia; female 0 / no chance;
(0.25(25% / ¼) first baby having haemophilia);

or

X_HX_h X_HY;
$X^HX^H + X^HX^h + X^HY + X^h Y$;
X^hY is a sufferer

3 max

[5]

14

(a) mutations;
which are different / at different positions in the gene;

2

(b) (i) either dominant or recessive allele;

1

(ii) A^hA^h BB, A^haBB, A^hA^h Bb, A^haBb;

(allow 1 mark for 2 or 3 correct answers)

2

(iii) temperature lower at extremities;enzyme active / not denatured;

2

(c) if allele A is present (normal) tyrosinase / enzyme is produced, so it doesnot matter what other allele is present / explanation of why heterozygote is same phenotype as double dominant in terms of enzyme produced; phenotype / rabbit is black as both have alleles A and B**;**

2

[9]

15

(a) epistasis;

one gene influences the expression of another / description using example in question;

2

(b) aaDD, aa Dd (or DDaa, Ddaa);

1

(c) (i) AaDd (or DdAa);

1

(ii) aadd, Aadd (or ddaa, ddAa);

1

(iii) cross with black individual / genotype aaDd or aaDD;genotype is Aadd if agouti offspring / genotype is aadd if no agouti offspring; *Accept*; repeat

cross using original parents many times; ratio is 4 albino : 3 agouti : 1 black if Aa, or 2 albino : 1 agouti : 1 black if aa;

2

[7]

16 (a) (i) paternal grandmother: $\mathbf{X^GX^G}$ or $\mathbf{X^GX^g}$

1

(ii) grandparent genotypes: [$\mathbf{X^gY}$] [$\mathbf{X^gX^g}$] [$\mathbf{X^gY}$]; gametes: [$\mathbf{X^G}$ and $\mathbf{X^g}$, or $\mathbf{X^G}$ only] [$\mathbf{X^g}$ and **Y**] [$\mathbf{X^g}$] [$\mathbf{X^g}$ and **Y**]; parents genotypes: [$\mathbf{X^GY}$] [$\mathbf{X^gX^g}$] gametes: [$\mathbf{X^G}$ and **Y**] [$\mathbf{X^g}$] daughter: [$\mathbf{X^GX^g}$];

(all correct = 3 marks);
(max 2 if no distinction between pairs of gamete genotypes, e.g. comma, space or circle);
(allow omission of gametes clearly not involved in next generation);
(all males XY and females XX = 1 mark, if no other marks);

3

(iii) nil;
X chromosome, without **G** allele, inherited from mother / Y must be inherited from father, not $\mathbf{X^G}$;

2

(b) X and Y chromosomes are different sizes / shapes;
chromatids unable to line up and form bivalent / only short pairing region / most of length not homologous;

2

[8] (a) 6;

17

1

(i) chromosomes are arranged in (homologous) pairs / bivalents;crossing over / chiasma present / exchange of genetic information; bivalents arranged independently;

2 max

(ii) separation / spliting / pulling apart of homologous chromosomes / pairs of chromosomes;

(must give indication that one chromosome moves to each side)
(must be in the context of meiosis – not chromatid movements and not chromosomes separate)

pulled at centromere / by spindle / fibres;

2

(c) (i) the short arm of both chromosomes labelled on the middle homologous pair;

*(**B** and **b** must be labelled on separate chromosomes)*

1

(ii) 8 = 2 marks; working showing genotypes with 1 allele from each pair
(for example, **B C D**) = 1 mark

2

[8]

18

(a) gene located on X / Y / one sex chromosome;

(allow gene on X or Y chromosome, not X and Y)

1

(b) (i) black;

1

(ii) $\mathbf{X^GX^g}$;

(lose this mark if the wrong genotype is given for the female in (iii))
(must show X chromosomes to gain the mark)

1

correct parent gametes
($\mathbf{X^g}$ and **Y** from male, $\mathbf{X^G}$ and $\mathbf{X^g}$ from female);
correct offspring genotypes ($\mathbf{X^gX^g}$, $\mathbf{X^GX^g}$, $\mathbf{X^GY}$, $\mathbf{X^gY}$);
correct link of offspring genotypes with phenotypes;
$\mathbf{X^gX^g}$ black female
$\mathbf{X^GX^g}$ tortoiseshell female
$\mathbf{X^GY}$ ginger male
$\mathbf{X^gY}$ black male

(correct gametes, offspring genotypes and link with phenotypes based on incorrect parent genotype = 3 marks)

3

(c) $\mathbf{X^GY\ dd}$; correct male kitten genotypes ($\mathbf{X^gY\ Dd}$ and $\mathbf{X^gY\ dd}$); correct link of kitten genotypes with phenotypes;

(ignore female kittens)

$\mathbf{X^gY\ Dd}$ black
$\mathbf{X^gY\ dd}$ grey

(correct kitten genotypes and phenotypes based on incorrect parent genotype = 2 marks)

3

[9]

19

(a) sandy stated as heterozygous / suitable allusion to alleles;

suitable cross chosen; (as in table)

N.B. second two points linked, not stand-alone

explained why could not be codominance;

N.B. Second two points linked, not stand alone

Suitable cross	*Reason why **not** codominance*
3 and 4	Offspring should all be sandy
10 and 11	Offspring should all be sandy
7 and 8	Offspring should all be red

BUT if candidate assumes sandy is homozygous, mark accordingly e.g. "look at cross 1 and 2; all their offspring would be sandy;" and not that, if red or white then identified as heterozygote, then full 3 marks are still possible.

3

(b) 11 aabb,

10 = AaBb, (*N.B. only possibility, not A-B-*)
2 = A_bb or aa B- (or one possible genotype);

if all 3 correct - 2 marks / if 2 correct - 1 mark; one or fewer - 0 marks

2

(c) 1 mark for each element of clear explanation i.e.
- choice of a suitable piece of evidence;
- explaining why Hypothesis 2 could not account for the observed result;

(only cross really possible is 1 and 2) i.e. if sandy was aaB_, individuals 1 and 2 would both have been aaB; so their offspring could only be either white or sandy (as no A alleles present);

2

(d) (*Mark line by line, not to 'first error': do not allow for consequential errors*)

Individual 18 *Other parent*

Parental genotypes *this* **AaBb;** *No mark for (AaBb)*

Parental gametes **AB Ab aB ab** *and* **Ab ab**;

Offspring genotypes

AABb	**Aabb**	**AaBb**	**Aabb**
AaBb	**Aabb**	**aaBb**	**aabb**

(Punnett not necessary

Offspring phenotypes	**red**	**sandy**	**white**
Expected ratio	**3**	**4**	**1;**

4

[11] (a) (Gene 1) allele A makes enzyme converting J to K / colourless to red;

20

Allele a produces no / non-functional enzyme;
(Gene 2) allele B makes enzyme converting K to L / red to purple;
Allele b produces no / non-functional enzyme;
("Recessive alleles produce no / non-functional enzyme" = 2)
White flowers result from genotype aa;
... regardless if B or b / even if aaB_ ;
Colourless (substance) / J produces white;
Red flowers when A_ bb / enzyme 1 only;
Purple flowers when A_ B_ / enzymes 1 and 2;

6 max

(b) (i) (1) (red parent) AAbb;

(2) (white parent) aaBB;

2

(ii) F_1 are AaBb;
F_2 ratio of 9 : 3 : 4;
Purple : red : white;
Suitable working shown;

4

(c) (i) aabb, aaBb, and aaBB; (allow aabb & aaB_)

1

(ii) (Crush each type of white petal to make an extract, and) add some of the (red) pigment / K, to petal OR incubate with K;
(extract becoming) purple is identified as aaBB OR that staying red, after K is added, is aabb;

2

[15] (a) Correct answer: 1.25;

21

Ignore working

OR (if wrong answer)

$$\frac{\text{measurement in µm}}{40000} \;/\; \frac{\text{measurement in mm}}{40}$$ = 1 mark

125 but wrong order of magnitude = 1 mark

2 (ii) **C** has myosin / thick (and actin / thin) filaments;

OR

A has only actin / thin (/ no myosin / no thick) filaments;

1 max

(b) When contracted:

Thick & thin filaments/myosin & actin overlap more;

Interaction between myosin heads & actin / cross-links form;

Movement of myosin head;

Thin filaments / actin moved along thick filaments / myosin;

Movement of thin filaments / actin pulls Z-lines closer together;

Displacement of tropomyosin to allow interaction;

Role of Ca^{2+};

Role of ATP;

Allow ref. to 'sliding filament mechanism' / described if no other marks awarded

4 max

(c) (i) 8 has DMD but 3 and 4 do not / 12 has DMD but 6 and 7 do not / neither parent has the condition but their child has;

Allow parents 3 and 4 give 8, parents 6 and 7 give 12

1

(ii) 4 ***AND*** 7;

1

(iii) Parental genotypes: 6 = $\mathbf{X^DY}$ AND 7 = $\mathbf{X^DX^d}$

AND

Gametes correct for candidate's P genotypes – e.g.

$\mathbf{X^D}$ and $\mathbf{Y}$ + $\mathbf{X^D}$ and $\mathbf{X^d}$;

Offspring genotypes <u>correctly derived</u> from gametes e.g.

$\mathbf{X^DX^D}$ + $\mathbf{X^DX^d}$ + $\mathbf{X^DY}$ + $\mathbf{X^dY}$;

Male offspring with MD correctly identified: $\mathbf{X^dY}$;

Probability = 0.25 / correct for candidates offsprings genotypes;

Accept ¼ / 1 in 4 / 1:3 / 25%

NOT '3:1' / '1:4'

4

(d) (i) No gene fragment **G**;

1

(ii) Only one copy of gene fragment **F**;

Male has only one X-chromosome / is XY
(c.f. female has two / is XX);

2

(iii) 10 has only one copy of gene fragment **G**;

10 has only one normal X-chromosome / has one abnormal / $X^{d}X^{D}X^{d}$ has only one normal allele / has one X / is $X^{D}X$ / is heterozygous;

11 has two normal X-chromosomes / has 2 normal alleles / is $X^{D}X^{D}$ / has not got X^{d} / has 2 copies of (F and) G;

3

(e) (i) To prevent rejection / prevent antibody production vs. injected cells / injected cells have (foreign) antigen (on surface);

1

(ii) Shows effect of <u>cells</u> / not just effect of injection / not just effect of salt solution;

1

(iii) Only one person tested so far – need more to see if similar results /need more to see if reliable;

Need to assess if new (dystrophin positive) muscle fibres are functional / if muscle becomes functional;

Can't tell how widespread effect is in the muscle / sample taken near injection site;

Need to test for harmful side effects;

Need to test if successful for other mutations of dystrophin gene;

Need to assess permanence / longevity of result/insufficient time allowed in investigation;

(In this patient) only small response / %;

Further sensible suggestion;

4 max

[25] (a) Parents without CF → offspring with CF / 1 + 2 → 6 / 7 + 8 → I0;

22

Each parent must have CF allele / offspring receives CF allele from both parents / both parents heterozygous / both carriers;

2

(b) **Nn** and **Nn** (no mark since awarded in (a) already)

Accept alternative symbols

N n and **N n**;

Ignore X and Y

NN and **Nn** and **Nn** and **nn**;

Correct allocation of phenotypes to genotypes;

Probability = 0.125;

Accept answers expressed as chance rather than probability, eg 1 in 8 / 1 to 7 / 12.5%;

4

[6] (a) Daughter (C) does not have the condition / one child doesn't have it;

23

Accept converse arguments (If candidates see it purely as a genetic cross diagram) D is heterozygous because E is unaffected;

Parents must have been carriers of normal / healthy recessive/ if recessive then parents homozygous (so all children affected);

D has cancer, so the cancer allele must be dominant;

2

(b) Father (A) would pass on X chromosome to daughter;
She is not affected;

Accept that if D's X chromosome carried 'it', then E would be affected.

2

(c) Only 25 / young so don't know if cancer will develop;

Accept E must be homozygous recessive/have two recessive alleles;

Don't know if her father was heterozygous or homozygous;

So no chance of cancer / no more chance than rest of the population;

If heterozygous, she has a 50% chance of carrying the allele/gene;
If homozygous, she has a serious risk of cancer.

2 max

(d) Mutation / mutagen changes DNA of cell;
Damaged DNA not repaired / cells not killed / apoptosis doesn't happen; Mutation leads to loss of control / uncontrolled cell division;
(Some of these) cells carried to other parts of the body.

3 max

[9]