

1. (a) (i) Substitutions;
only affect specific codons/not all codons affected;
therefore only a few amino acids affected;
or
Degenerate code;
some amino acids have more than one codon;
may mean mutations code for same amino acids/
only a few amino acids affected; max 2
- (ii) Frame shift/sequence of bases/codons/triplets changed from that
point on;
sequence of amino acids changed;
protein will have different tertiary structure;
active site affected; max 3
- (b) Genetic probe is single stranded DNA;
with complementary base sequence/is a complementary strand;
chains of DNA separated (by heating);
probe attached by hydrogen bonding;
probe labelled/radioactive/fluorescent so can be detected;
(If probe described as RNA, then max =2) max 3
- (c) (i) I^A and I^O ; 1
- (ii) Blood group B; 1
- (iii) Probability of child being boy indicated as 0.5 and probability
of child being blood group A indicated as 0.5;
0.25 or other correct expression; 2
- (d) (i) Person with blood group O has no antigens/has unchanged antigens;
cannot provoke a response by antibodies/cannot cause a
reaction/agglutination/with anti A or anti B;
(Not just 'immune response') 2
- (ii) Person with blood group O has both anti A and anti B/
has both antibodies;
will react with/agglutinate any red cells with any antigens/
A/B / AB / have antigens which will react;
(do not allow 'attack') 2
- (e) (i) 0.27; 1
- (ii) Blood groups B and O have anti-A antibodies;
these match/fit A antigen;
which has similar shape to surface proteins on smallpox virus;
recognition as non-self
may \therefore also agglutinate/react with/fit/match smallpox antigen; max 3

[20]

2. (a) (i) Time interval of 1 month / too long;
 Large number of mice born / added to the population in this time /
 die / lost from population;
OR
 12 hours is too short a time;
 For mice to mix in population / be recaptured;
OR
 In non-seed years number of mice is small;
 So may not catch any / any marked mice; 2
Reject answers about points not covered in the question.
- (ii) Number of captures will vary with number of traps set /
 number of traps varies;
 Standardises results;
 Allows results to be compared; 2 max
- (b) (i) Less than 5% / 1 in 20 probability;
 Of results being due to chance / luck;
Accept converse argument relating to biological significance. 2
- (ii) More food;
 Therefore mice able to produce more young / more mice survive; 2
- (c) (i) Mass will vary with sex / one sex is lighter / heavier /
 females may be pregnant; 1
- (ii) Tooth wear linked to age / diet;
 Confines sample to adult mice / mice eating same food;
 Otherwise age / food contributes to variation / mass; 2 max
- (d) (i) Smaller surface area to volume ratio;
 So lose less heat;
OR
 More (subcutaneous) fat;
 Insulation;
OR
 More respiration;
 More heat produced; 2

(ii) Variation in size is genetic;
 Selection for / against one extreme (*general point not related to data*) / for large mice / against small mice;
 Only larger mice will (survive and) breed / pass on genes;
 Leads to increase in mean mass;
 In cold conditions (related to figure); 3 max

(e) (i) Grey by grey;
 Produces some black; 2

(ii) Find frequency / percentage / proportion of black mice;
 Square root;
 Use Hardy-Weinberg equation; 2 max

[20]

3. (a) (different) forms of a gene; 1

(b) (i) $I^A I^O$; $I^B I^O$; $I^A I^B$; $I^O I^O$;
 (4 correct = 2 marks; 3 or 2 correct = 1 mark; 1 correct = 0) max 2

(ii)	genotypes	$I^A I^O$		$I^B I^O$		1
	gametes	I^A	I^O	I^B	I^O	1
	genotypes	$I^A I^B$	$I^A I^O$	$I^B I^O$	$I^O I^O$	
	phenotypes	AB	A	B	O;	1

[6]

4. (a) lays many eggs or large number of offspring - more information /
 low sampling error;
 short life cycle - short generation time / results obtained quickly;
 male and female easily distinguished - for mating / sex linkage;
 small size - easy to handle / large numbers can be kept /
 small space required; max 3

(b) (i) GgNn; 1

(ii) Gn gn; 1

(c) 9:3:3:1; 1

[6]

5. (a) lack of skin / eye / hair pigment/ fair skin/ hair/poor co-ordination; 1

(b) alteration in sequence / deletion / substitution / addition of nucleotides/bases;
 incorrect amino acids inserted into polypeptide / protein;
 alters active site / substrate cannot bind; 3

(c) (i) Parental pheno types normal x normal
 Parental genotypes Nn x Nn
 Genotypes of gametes N+n x N+n; 1
 Genotypes of children NN Nn Nn nn
 Phenotypes of children Normal Normal Normal Affected; 1
 (ii) 25% / 1/4 / 0.25 / 1 in 4; 1

[7]

6. (a) 1

<i>parents</i>	X^bX^bTt		X^BYtt ;	
<i>gametes</i>	X^bT ,	X^bt	X^Bt ,	Yt ;
<i>genotype</i>	X^BX^bTt	X^bYTt	X^BX^btt	X^bYtt ;
<i>phenotypes</i>	Female	Male	Female	Male
	Colour vision Tongue-roller	Colour blind Tongue-roller	Colour vision non-roller	Colour blind non-roller

(b) males have only one X chromosome so if allele present they are affected /
 females have two X chromosomes must be homozygous recessive; 1

(c) All males possess Y chromosome so all affected/
 Only males possess Y chromosome so no females affected; 1

[6]

7. (a) (i) cyanogenic, (ii) non-cyanogenic;
 in (i) both enzymes are present both dominant alleles are present;
 in (ii) enzyme A is absent no formation of cyanogenic
 glucoside/hydrogen cyanide; 3

(b) (i) gametes of both parents correct AB, Ab, aB, ab:
 genotypes of all offspring correct;
 (ii) 9 cyanogenic:7 non-cyanogenic; 3

- (c) (i) high frequency of dominant alleles at low altitude/low frequency of dominant alleles at high altitude/converse for recessive alleles;
- (ii) idea of selection against cyanogenic at high altitude and non-cyanogenic at low altitude;
variation in cyanogenesis is present in population;
slugs eat more non-cyanogenic plants; freezing injures more cyanogenic;
at low altitude more cyanogenic survive to reproduce/converse at high altitude;
pass alleles on to next generation;
so higher frequency of dominant alleles in next generation/converse at high altitude;

6

[12]

8. (a) (i) specific cross identified - 3 ,4 & 8 or 10, 11 & 12 /Rh negative phenotype produced from parents which are both Rh positive; 1
- (ii) with sex linkage daughter cannot have (recessive) condition unless male parent has the condition;
as male passes X chromosome to his daughter; 2

- (b) (i) $Rr X^H X^h$;
- (ii) $rr X^h Y$; 2

(c) $P(rr) = \frac{1}{4}$; $P(X^h Y) = \frac{1}{4}$; probability = $\frac{1}{16}$ / 6.25% / 0.0625;

OR

Punnett square with first two marking points-
genotypes of gametes of one parent correct;
genotypes of gametes of other parent correct;
probability = $\frac{1}{16}$ / 6.25% / 0.0625; 3

[8]

9. (a) Parental genotypes $Hb^A Hb^S$ $Hb^A Hb^S$;
- Gamete genotypes Hb^A Hb^S Hb^A Hb^S
- Children's genotypes $Hb^A Hb^A$ $Hb^A Hb^S$ $Hb^A Hb^S$ $Hb^S Hb^S$;
- $Hb^S Hb^S$; clearly defined as having sickle-cell anemia; 3
- (b) 2 marks 0.0112/11.2%
- 1 mark Candidate shows "total" number of sickle cell alleles = 16 + 96; 2

- (c) (i) $Hb^A Hb^A$ individuals are more likely to die of malaria;
 $Hb^S Hb^S$ individuals likely to die of condition before maturity;
 More heterozygotes survive;
 Crosses between heterozygotes keeps frequency of Hb^S allele high; max 3
- (ii) Coincidence between distribution of malaria and sickle-cell allele;
 Could be another factor that influences both; 2
- (d) Effective treatment for malaria linked to advantage / no disadvantage
 to $Hb^A Hb^A$
 If more $Hb^A Hb^A$ individuals survive, frequency of Hb^S allele would fall; 2

[12]

10. (a) recessive only expressed (in the phenotype) when
 homozygous 1
 sex-linked gene is on the X chromosome (in humans)/
 Y chromosome. 1
- (b) (i) 3 and 4 produce unaffected male/8 / female/10, so must
 carry recessive;
 but both affected by nail-patella which must be dominant. 2
- (ii) 3 inherits X from mother, who is not affected;
 if sex-linked, 3 would have nail-patella on X chr and
 would pass on to all female offspring;
 10 is recessive female, so gene not sex-linked. max 2

[6]

11. (a) endoscope /cytology / CAT scan / biopsy (*reject X ray*) 1
- (b) invade surrounding tissues;
 (malignant cells) enter blood / lymph/metastasis;
 cause tumours in other parts of body / spread to other parts (*reject infect*) max 2
- (c) genotypes of parents male Aa and female aa;
 genotypes of alleles male A or a and female a
 genotypes of offspring Aa and aa in equal numbers / chance of Aa 0.5 or 1 in 2 3
- (d) all individuals with allele develop / aware of disease;
 therefore might choose not to have children;
 OR carriers may be unaware that they have allele/are unaffected;
 and therefore have children 2

[8]

12. (a) alternative form of a gene; 1
- (b) (i) parents heterozygous; correct gametes of parents clearly labelled with C-N allele being recessive; correct genotypes with child with C-N syndrome indicated; 1
- (ii) individuals with C-N allele present in founder community; in closed community higher frequency of allele than in general population/higher frequency of carriers; greater chance of inbreeding; greater chance of two recessive alleles coming together; max 3
- (c) Individuals with C-N survive to reproduce; greater chance of allele being passed on; higher frequency of C-N allele in population; 2

[7]

13. (a) Codominance; (Allow incomplete / inheritance without dominance) 1
- (b) $X^B Y$ OR $B(-)$; 1
- (c) Parental genotypes are given: $X^R X^R$ ($X^B Y$) - no mark
 Offspring 1 genotypes: $X^R X^B$ $X^R Y$;
 Offspring 2 genotypes: $X^R X^R$ $X^R X^B$ $X^R Y$ $X^B Y$;
 Offspring 2 phenotypes: round eyed female wide-bar female round eye male bar-eye male; 3
 Ratio: 1 : 1 : 1 : 1

(Ignore ratio unless it contradicts: be alive to other possible ratios)
 (No marks as such for "gametes", though may inform markers where unclear.)

[5]

14. (a) The higher the altitude, the lower the frequency (or converse); Below 400m altitude, frequency levels off / pretty constant; 2

(b) (*Higher frequencies found at certain (low) altitudes because*)
 Malaria found mainly among people at low altitudes;
 Because warmer here **OR** more sources of still / slow-moving water;
 t allele / heterozygous condition confers some resistance
 against malaria;
 Selection operates / heterozygotes favoured over
 homozygous (dominant); 3 max

(c) Mainland Italians didn't bring / import the t allele with them
OR hadn't been exposed previously to malaria;
 Malaria not / less of a factor in Sardinia since Carloforte established;
 Insufficient time / generations for selection to operate / have an effect; 2 max

[7]

15. (a) (Gene 1) allele A makes enzyme converting J to K / colourless to red;
 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) F₁ are AaBb;
 F₂ 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]

16. (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

<i>Suitable cross</i>	<i>Reason why not codominance</i>
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)*

	<i>Individual 18</i>	<i>Other parent</i>
<i>Parental genotypes</i>	AaBb;	<i>No mark for this (AaBb)</i>

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]

17. (a) (i) *diagram should indicate:*
(appropriate) separation;
and then either: homologous partners distinguished;
chromosomes shown made up of two chromatids; 2
- (ii) TB, Tb, tB, tb; 1
- (b) (i) if chromosomes segregate without crossing over, only two gametic
types possible (TA & ta);
crossing over enables exchange of chromosomal/genetic material
(between them);
so new/different combinations of alleles produced (or specific example);
(below) any 2 from 3 (approach may also be diagrammatical) 2
- (ii) more normal gamete types/crossing over (between loci) necessary/
rareness of event; 1
- (iii) presence of chiasma/chiasmata; or drawn 1

- (c) (1) independent assortment/random alignment of chromosomes;
new arrangement of alleles;
- (2) random fertilisation;
chance combinations of gametes;
- (3) mutation (or suitable description of);
creates new alleles/allelic combinations (by changes in DNA);
any two 'causes', to maximum of 4 from 6
- (NOTE in any answer, full credit can be achieved only within
TWO of possible three factors)*
- 4

[11]

18. (a) recessive,
only expressed in phenotype if homozygous;
codominant alleles,
both expressed (in phenotype), if both present,
- 2

- (b) (i) F_1 , - $F^B F^W$;
gametes clearly indicated – F^B and F^W ;
 F^2 genotypes correct and in correct order –
 $F^B F^B$ $F^W F^W$ $F^B F^W$
working clearly set out;
- 4

- (ii) chance related to mating;
random fusion of gametes;
small sample size;
differential mortality;
- 2 max

[8]

19. (a) allele,
one form of a (specific) gene;
- 1
- sex-linked,
- 1
- on sex chromosomes/X/Y;

- (b) (i) 3 and 4 do not show the condition but 9/one male does;
4 must be carrier;
- OR
- 1 affected but not daughter/4;
who gets X from father;
- 2

- (ii) grandfather/1 passed on his (affected) X chromosome to his daughter/4;
 who was unaffected, because of the 'normal' X inherited from her mother/2;
 9 inherited his X chromosome from his mother/4; 2 max

[6]

20. (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) $X^G X^g$; 1

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

correct parent gametes

(X^g and Y from male, X^G and X^g from female);

correct offspring genotypes ($X^g X^g$, $X^G X^g$, $X^G Y$, $X^g Y$);

correct link of offspring genotypes with phenotypes;

$X^g X^g$ black female

$X^G X^g$ tortoiseshell female

$X^G Y$ ginger male

$X^g Y$ black male 3

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

- (c) $X^G Y dd$;
 correct male kitten genotypes ($X^g Y Dd$ and $X^g Y dd$);
 correct link of kitten genotypes with phenotypes; (ignore female kittens) 3

$X^g Y Dd$ black

$X^g Y dd$ grey

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

[9]

21. (a) (i) paternal grandmother: $X^G X^G$ or $X^G X^g$ 1

(ii) grandparent genotypes: [X^gY] [X^gX^g] [X^gY];
 gametes: [X^G and X^g , or X^G only] [X^g and Y] [X^g] [X^g and Y];
 parents genotypes: [X^GY] [X^gX^g]
 gametes: [X^G and Y] [X^g]
 daughter: [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 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]

22. (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]

23. (a) Insecticide resistance *already* in population;
 (resulting) from *mutation*;
 resistant insects are not killed (by insecticide)/survive;
 (And are able to) reproduce/breed;
 passing on the relevant *allele/gene* to the next generation/offspring;
 resulting in *increasing* frequency of resistance allele in population. max. 5

(b) (i) Surviving/resistant moths are homozygous recessive/rr;
 moths from untreated fields/non-resistant will be RR/Rr;
 crossing these produces heterozygotes/Rr;
 non resistant are susceptible and *die*;
Allow annotated diagrams

(ii) (If the allele were dominant) all heterozygotes would survive
 (and be able to breed);
 pass on dominant allele/gene;
 increasing frequency/number/of resistant individuals/moths; max. 6

[11]

24. (a) EITHER: $q^2 = 0.36 / q = 0.6/0.61$;
 $p = (1 - 0.6) = 0.4/0.39$;
 $48/47.9 = 3$ marks

OR (If no correct calculations)

Allow 1 mark for use of H – W equation:

$p + q = 1 / p^2 + 2pq + q^2 = 1$ max. 3

(b) No selection;
 random mating/no sexual selection;
 large population/gene pool;
 no emigration/immigration/no migration/isolated population;
 no mutation;
 equally viable gametes/all equally fertile;
 generations do not overlap; max. 2

[5]

25. The answer to this question requires continuous prose. Quality of language should be considered in crediting points in the mark scheme. In order to gain credit, answers must be expressed logically in clear scientific terms.

- 1 Variation (in beak size) already present in population;
- 2 (Variation) due to inheritance / due to mutation;
- 3 Beak size relates to food size;

(On Albermarle):

- 4 Competition between birds of similar beak size /
birds with more extreme beak sizes get enough food /
reduce competition;
- 5 OR converse → best adapted survive / selected for / larger beak
sizes (*in G. fortis*) survive / larger beak an advantage;

(On 2nd island):

- 6 *G. fortis* has smaller seeds available (since no competition);
- 7 *G. fortis* does not need large beak to survive / to feed;
- 8 (Survivors) reproduce;
- 9 Pass on (relevant) allele(s) / gene(s) to offspring;
Worth 2 marks, because subsumes 'survivors reproduce'
marking point
- 10 Increasing frequency of appropriate allele(s) /
gene(s) (in population); 7 max

[7]

26. (a) (i) Time interval of 1 month / too long;
Large number of mice born / added to the population in this time /
die / lost from population;
OR
12 hours is too short a time;
For mice to mix in population / be recaptured;
OR
In non-seed years number of mice is small;
So may not catch any / any marked mice; 2
Reject answers about points not covered in the question.
- (ii) Number of captures will vary with number of traps set /
number of traps varies;
Standardises results;
Allows results to be compared; 2 max
- (b) (i) Less than 5% / 1 in 20 probability;
Of results being due to chance / luck;
Accept converse argument relating to biological significance. 2
- (ii) More food;
Therefore mice able to produce more young / more mice survive; 2

- (c) (i) Mass will vary with sex / one sex is lighter / heavier / females may be pregnant; 1
- (ii) Tooth wear linked to age / diet;
Confines sample to adult mice / mice eating same food;
Otherwise age / food contributes to variation / mass; 2 max
- (d) (i) Smaller surface area to volume ratio;
So lose less heat;
OR
More (subcutaneous) fat;
Insulation;
OR
More respiration;
More heat produced; 2
- (ii) Variation in size is genetic;
Selection for / against one extreme (*general point not related to data*) / for large mice / against small mice;
Only larger mice will (survive and) breed / pass on genes;
Leads to increase in mean mass;
In cold conditions (related to figure); 3 max
- (e) (i) Grey by grey;
Produces some black; 2
- (ii) Find frequency / percentage / proportion of black mice;
Square root;
Use Hardy-Weinberg equation; 2 max

[20]

27. (a) Organisms cannot interbreed/ breed or mate or reproduce with another group/ incompatible gametes/ wrong courtship behaviour/ other valid; 1

- (b) 1 Populations separated by physical barrier/ example;
 2 No mixing of gene pools;
 3 Different selection pressures;
 4 Become adapted to local environment;
 5 Survive and reproduce;
 6 Mutation in one group (different from other group);
 7 Change in allele frequencies; [*Reject: Gene*]
 8 Isolated populations/ new species cannot interbreed; max 4
- [5]**

- 28.** (a) The alleles/genes / all the alleles/genes; [*Reject: "the no. of alleles/genes"*]
 In a population / in a group of organisms of one species (in an area); 2
- (b) (i) Correct answer: 0.22 / 22%;; = 2 marks
 Incorrect answer / no answer but frequency of white-flowered
 plants determined: $\frac{17}{344}$; = 1 mark max 2
- (ii) No selection/mating/pollination/fertilisation at random / no mutation
 /large population / no immigration/emigration; 1
- [5]**

- 29.** (a) Mutation/(spontaneous) change in a gene/change in DNA; 1
- (b) (i) Correct answer: 0/6;; 2 marks
 OR
 Use of 56 and $\frac{176}{2}$ or 88 / 56 × 2 or 112 and 176; 1 mark max 2
- (ii) 64; 1
- (c) (i) Correct answer = 42%;;; (only if $q^2 = 0.49$) 3 marks
 OR 0.42;;; 2 marks
 OR
 $p+q=1 / p^2 + 2pq + q^2 = 1 / p=1- 0.7 / q^2 = 0.49 / q = 0.7$;
 Answer = 2pq / use of appropriate numbers; 2 marks max 3

- (ii) 1. Parental genotypes correct: both $W^R W^S$ (ACCEPT 'RS')
- AND
- W^S (ACCEPT 'S') /gamete from each parent;
2. $W^S W^S$ (ACCEPT 'SS') / offspring formed and identified as susceptible;
- If different symbols:
- defined : max 2 marks
 - not defined max 1 mark (= pt.2) 2
- (iii) 1. Description: decrease + rate of decrease slows with time;
- Explanation: Any **three** from:
2. Resistant rats/rats with W^R allele survive
OR susceptible / $W^S W^S$ rats killed
 3. (more likely) to pass on W^R allele to offspring/less likely to pass on W^S
/higher proportion of next generation has W^R allele/lower proportion has W^S ;
 4. Chance of mating with $W^S W^S$ is reduced / $W^S W^S$ becomes rare;
 5. Rate of selection against W^S slows because W^S allele is in heterozygotes;
- max 4
- (iv) No selective advantage / All genotypes equally fertile;
- Large population;
- Random mating; (IGNORE 'random fertilisation')
- No mutation;
- No emigration/immigration; max 2

[15]

30. (a) 1. Occurs in an unchanging environment; 1
- +
2. (Initial range of values in which) mean is best adapted;
 3. Selection against extremes / selection for the mean;
 4. Mean/median/mode unaltered
 5. Range/S.D is reduced;
 6. Repeated over many generations;
 7. Increasing proportion of populations becomes well adapted to environment;
- max 4

- (b) Little green light reaches bottom as absorbed by surface dwellers / water;
 Red and blue not absorbed and so penetrate;
 Variation in pigments of sediment dwellers;
 Bacteria with chlorophyll at an advantage;
 As chlorophyll absorbs red and blue;
 (Survive to) reproduce in greater numbers;
 Pass on advantageous alleles/genes in greater numbers / increase in
 frequency of advantageous alleles in subsequent generations;
 Increase in frequency/numbers of bacteria with chlorophyll; max. 6

[11]

33. (a) similar characteristics / physically similar / DNA similar;
 breed among themselves;
 to produce fertile offspring;
 do not share same ecological niche with any other species; max 2

- (b) (i) isolation;
 no gene flow between populations;
 variation;
 different environmental factors;
 natural selection / selection for specific alleles / characteristics;
 change in allele / phenotype frequency;
 changes over a long period of time; max 4

- (b) (ii) more habitats / niches;
 more / greater range of food for herbivores;
 more / greater range of food for carnivores / predators;
 more detritus; max 2

- (c) colonisation / description e.g. seeds blown in / pioneer species;~
 succession;
 alteration of habitat / more humus / deeper soil;
 development of herbaceous / field layer;
 followed by shrub layer; max 4

[12]

34. (a) Do not share same ecological niche/
 do not produce fertile young if crossed/do not interbreed; 1

- (b) (i) magnirostris; 1
 (ii) Four; 1

- (c) Common ancestor varied;
 Due to mutation;
 Differences in local environment/food supply;
 Better adapted varieties survived and reproduced;
 Passing on genes for these characteristics;
 Habitat/behavioural isolation;

max 4

[7]

35. (a) (i) cyanogenic, (ii) non-cyanogenic;
 in (i) both enzymes are present both dominant alleles are present;
 in (ii) enzyme A is absent no formation of cyanogenic
 glucoside/hydrogen cyanide;

3

- (b) (i) gametes of both parents correct AB, Ab, aB, ab:
 genotypes of all offspring correct;
 (ii) 9 cyanogenic:7 non-cyanogenic;

3

- (c) (i) high frequency of dominant alleles at low altitude/low frequency
 of dominant alleles at high altitude/converse for recessive alleles;
 (ii) idea of selection against cyanogenic at high altitude and
 non-cyanogenic at low altitude;
 variation in cyanogenesis is present in population;
 slugs eat more non-cyanogenic plants; freezing injures more
 cyanogenic;
 at low altitude more cyanogenic survive to reproduce/converse at
 high altitude;
 pass alleles on to next generation;
 so higher frequency of dominant alleles in next generation/converse
 at high altitude;

6

[12]

36. (a) (i) maintain form/different phenotypes when grown in same environment;
 (ii) produce fertile offspring;

2

- (b) idea of natural selection against plants with upright form/upright plants fail to
 survive;reason why plants do not survive - plants with upright form fail to
 complete life cycle/out competed by low-growing plants for named
 resource/effect of low temperature/effect of low photosynthesis;

2

- (c) not isolated;
 transfer of genetic material/seeds/pollen between populations/cross
 pollination/cross breeding;
 so each population cannot evolve independently;

2

- (d) variation present in the species/large gene pool;
likely that some individuals will have the required characteristics/
alleles for survival, 2 [8]
37. (a) isolated population/group of flies/no gene flow;
variation/mutation (in population);
some able to use new food;
so less competition;
(survive and) reproduce to give new population. max 3
- (b) take flies from each population and interbreed;
if no fertile offspring, then different species/ if present,
same species. 2 [5]
38. (a) (i) 3,4,5 (must give all three) 1
(ii) 57 – 59mm 1
- (b) larger body has smaller surface area to volume ratio;
reduces heat loss;
OR
larger body has thicker/more fat;
better insulated/ reduces heat loss;
Reject - stay warm 2
- (c) mutations/source of inherited variation;
more birds with larger bodies survive and breed;
more chance of alleles/genes (for larger body)being passed on;
frequency of alleles/genes for larger body increases in population; 3 [7]
39. (a) variation between members of population/species;
predation/disease/competition results in differential survival;
some have adaptations that favour survival;
survive to reproduce/have more offspring/ pass on
their alleles/genes;
produces changes in frequency of allele /gene pool/
genotypes/phenotypes; 4 max

- (b) (i) reduces it;
homozygous much more;
correct use of figures, hetero by 29/30% and
homozygous by 92/94%; 2 max
- (ii) people without Hb^C lower survival rate, so less
likely to pass on Hb^A allele;
increasing chance of children where both parents
carry Hb^C;
homozygous Hb^C most likely to survive and pass on allele 2 max

[8]

40. (a) pesticide not biodegradable/broken down;
stored in tissues/fat;
persists in food chain/bioaccumulation/biomagnification;
animals higher up the food chain eating larger numbers of organisms
lower down; 3 max

- (b) mutation produced (allele/gene for) resistance;
(*reject mutation as a result of pesticide*)
variation within insect population / some insects able to survive application;
reproduce;
pass on alleles/genes; 3

- (c) pesticide is lipid soluble;
membranes contain lipid/phospholipid;
OR
pesticide fits into receptors/proteins on membrane;
passes through carrier proteins/facilitated diffusion /active transport; 2
(*points must be linked*)

[8]

41. (a) breed together;
if fertile offspring, then same species; 2

- (b) isolation of two populations;
variation already present due to mutations;
different environmental conditions / selection pressures;
selection of different features and hence different alleles;
different frequency of alleles;
separate gene pools / no interbreeding; 4 max

- (c) selection of mate dependent on colour pattern;
prevents interbreeding / keeps gene pools separate; 2

[8]

42. (a) genetic variation/ variation in gene/allele(s) in populations for cyanide production; colder/below 0°C (January) areas, cyanogenic plants die in this cold/acyanogenic survive; non-cyanogenic allele/gene passed on more often/its frequency increases; warmer (January) areas cyanogenic plants at advantage, because of less herbivore selection pressure/feeding; so cyanogenic survive more often to pass on cyanogenic allele/gene. 4 max

- (b) large (and equal) number of quadrats in each area;
(reject several)
random sampling method, described;
(accept described 'systematic' method)
percentage cover/point hits per quadrat/count plants;
mean/average value for each area;
statistics test to see if differences significant. 4 max

[8]

43. (a) (i) Accurate means without error/free from mistakes when callipers used;
Reliable means that figure can be reproduced when measurement Repeated/show little variation about true value; 2

- (ii) If data unreliable, there will be a wide range of values;
Large standard deviation;
The higher the figure on the top line of the equation, the greater
The percentage measurement error; 2 max

- (b) (i) Plot graph of mean skull breadth against mean cranial volume/
scatter diagram;
Draw line of best fit / calculate coefficient of correlation;
Look for figures close to +1 or -1; 2

- (ii) Skull breadth is a linear measurements/can be measured with a single measurement/less prone to error/Cranial volume more difficult to measure because...; 1

- (iii) Could distinguish between large male polecats and small female ferrets;
 Little overlap in standard deviations;
 Mean measurements for female polecats and male ferrets are very similar; 3
- (c) Scientists could use method suggested/protocol established in earlier paper (thus saving time);
 Findings more likely to be reliable if they replicate the findings of others; 2
- (d) Some stomachs may contain more than one type of prey item; 1
- (e) Unidentified bird remains small percentage of total prey/found in few stomachs;
 Significant numbers of rabbits/rats eaten and these are pests; 2

[15]

44. (a) males are XY and females XX / males have one X chromosome and females two X 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, HHX^bX^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]

45. (a) mutations;
 which are different/at different positions in the gene; 2
- (b) (i) either dominant or recessive allele; 1

	(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]
48.	(a)		Normal sight;	1	
	(b)		Nn ; Must have at least one N allele as she has the condition and must pass on an n allele to her normal sighted children;	2	
	(c)		Two marks for correct answer of $\frac{1}{4}$ / 0.25 / 25%; One mark for incorrect answer that determines probability of next child having night blindness as $\frac{1}{2}$ / 0.5 / 50%;	2 max	[5]
49.	(a)	(i)	Avoid bias/can only apply statistical test/Hardy-Weinberg expression to randomly collected data;	1	
		(ii)	Give credit for any method which would ensure collection of a random sample from trees e.g. beating tray; <i>Q Note that specification does not require specific knowledge therefore the use of specific terminology such as "beating tray" is not required here.</i>	1	
	(b)		Two marks for correct answer of 49% red and 51% black; One mark for incorrect answer in which p/frequency of black allele/B is Identified as 0.3 and q/frequency of black allele/B as 0.7;	2	
	(c)	(i)	Increase in the frequency of the red/b allele from autumn to spring/in all years; Therefore frequency of black/B allele decreased and fewer black ladybirds in spring;	2	
			<i>Q The terms allele and gene must be used correctly but penalise only once</i>		
		(ii)	Black ladybirds would become more active so respiration rate increases; Deplete food reserves;	2	[8]

50. (a) Insecticide resistance *already* in population;
 (resulting) from *mutation*;
 resistant insects are not killed (by insecticide)/survive;
 (And are able to) reproduce/breed;
 passing on the relevant *allele/gene* to the next generation/offspring;
 resulting in *increasing* frequency of resistance allele in population. max. 5

(b) (i) Surviving/resistant moths are homozygous recessive/rr;
 moths from untreated fields/non-resistant will be RR/Rr;
 crossing these produces heterozygotes/Rr;
 non resistant are susceptible and *die*;
Allow annotated diagrams

(ii) (If the allele were dominant) all heterozygotes would survive
 (and be able to breed);
 pass on dominant allele/gene;
 increasing frequency/number/of resistant individuals/moths; max. 6

[11]

51. (a) EITHER: $q^2 = 0.36 / q = 0.6/0.61$;
 $p = (1 - 0.6) = 0.4/0.39$;
 $48/47.9 = 3$ marks

OR (If no correct calculations)

Allow 1 mark for use of H – W equation:

$p + q = 1 / p^2 + 2pq + q^2 = 1$ max. 3

(b) No selection;
 random mating/no sexual selection;
 large population/gene pool;
 no emigration/immigration/no migration/isolated population;
 no mutation;
 equally viable gametes/all equally fertile;
 generations do not overlap; max. 2

[5]

52. The answer to this question requires continuous prose. Quality of language should be considered in crediting points in the mark scheme. In order to gain credit, answers must be expressed logically in clear scientific terms.

- 1 Variation (in beak size) already present in population;
- 2 (Variation) due to inheritance / due to mutation;
- 3 Beak size relates to food size;

(On Albermarle):

- 4 Competition between birds of similar beak size /
birds with more extreme beak sizes get enough food /
reduce competition;
- 5 OR converse → best adapted survive / selected for / larger beak
sizes (*in G. fortis*) survive / larger beak an advantage;

(On 2nd island):

- 6 *G. fortis* has smaller seeds available (since no competition);
- 7 *G. fortis* does not need large beak to survive / to feed;
- 8 (Survivors) reproduce;
- 9 Pass on (relevant) allele(s) / gene(s) to offspring;
Worth 2 marks, because subsumes 'survivors reproduce'
marking point
- 10 Increasing frequency of appropriate allele(s) /
gene(s) (in population); 7 max

[7]

53. (a) (i) Time interval of 1 month / too long;
Large number of mice born / added to the population in this time /
die / lost from population;
OR
12 hours is too short a time;
For mice to mix in population / be recaptured;
OR
In non-seed years number of mice is small;
So may not catch any / any marked mice; 2
Reject answers about points not covered in the question.
- (ii) Number of captures will vary with number of traps set /
number of traps varies;
Standardises results;
Allows results to be compared; 2 max
- (b) (i) Less than 5% / 1 in 20 probability;
Of results being due to chance / luck;
Accept converse argument relating to biological significance. 2
- (ii) More food;
Therefore mice able to produce more young / more mice survive; 2

- (c) (i) Mass will vary with sex / one sex is lighter / heavier / females may be pregnant; 1
- (ii) Tooth wear linked to age / diet;
Confines sample to adult mice / mice eating same food;
Otherwise age / food contributes to variation / mass; 2 max
- (d) (i) Smaller surface area to volume ratio;
So lose less heat;
OR
More (subcutaneous) fat;
Insulation;
OR
More respiration;
More heat produced; 2
- (ii) Variation in size is genetic;
Selection for / against one extreme (*general point not related to data*) / for large mice / against small mice;
Only larger mice will (survive and) breed / pass on genes;
Leads to increase in mean mass;
In cold conditions (related to figure); 3 max
- (e) (i) Grey by grey;
Produces some black; 2
- (ii) Find frequency / percentage / proportion of black mice;
Square root;
Use Hardy-Weinberg equation; 2 max

[20]

54. (a) Organisms cannot interbreed/ breed or mate or reproduce with another group/ incompatible gametes/ wrong courtship behaviour/ other valid; 1

- (b) 1 Populations separated by physical barrier/ example;
 2 No mixing of gene pools;
 3 Different selection pressures;
 4 Become adapted to local environment;
 5 Survive and reproduce;
 6 Mutation in one group (different from other group);
 7 Change in allele frequencies; [*Reject: Gene*]
 8 Isolated populations/ new species cannot interbreed; max 4
- [5]**

- 55.** (a) The alleles/genes / all the alleles/genes; [*Reject: "the no. of alleles/genes"*]
 In a population / in a group of organisms of one species (in an area); 2
- (b) (i) Correct answer: 0.22 / 22%;; = 2 marks
 Incorrect answer / no answer but frequency of white-flowered
 plants determined: $\frac{17}{344}$; = 1 mark max 2
- (ii) No selection/mating/pollination/fertilisation at random / no mutation
 /large population / no immigration/emigration; 1
- [5]**

- 56.** (a) Mutation/(spontaneous) change in a gene/change in DNA; 1
- (b) (i) Correct answer: 0/6;; 2 marks
 OR
 Use of 56 and $\frac{176}{2}$ or 88 / 56 \times 2 or 112 and 176; 1 mark max 2
- (ii) 64; 1
- (c) (i) Correct answer = 42%;;; (only if $q^2 = 0.49$) 3 marks
 OR 0.42;;; 2 marks
 OR
 $p+q=1 / p^2 + 2pq + q^2 = 1 / p=1- 0.7 / q^2 = 0.49 / q = 0.7$;
 Answer = 2pq / use of appropriate numbers; 2 marks max 3

- (ii) 1. Parental genotypes correct: both $W^R W^S$ (ACCEPT 'RS')
- AND
- W^S (ACCEPT 'S') /gamete from each parent;
2. $W^S W^S$ (ACCEPT 'SS') / offspring formed and identified as susceptible;
- If different symbols:
- defined : max 2 marks
 - not defined max 1 mark (= pt.2) 2
- (iii) 1. Description: decrease + rate of decrease slows with time;
- Explanation: Any **three** from:
2. Resistant rats/rats with W^R allele survive
OR susceptible / $W^S W^S$ rats killed
 3. (more likely) to pass on W^R allele to offspring/less likely to pass on W^S
/higher proportion of next generation has W^R allele/lower proportion has W^S ;
 4. Chance of mating with $W^S W^S$ is reduced / $W^S W^S$ becomes rare;
 5. Rate of selection against W^S slows because W^S allele is in heterozygotes;
- max 4
- (iv) No selective advantage / All genotypes equally fertile;
- Large population;
- Random mating; (IGNORE 'random fertilisation')
- No mutation;
- No emigration/immigration; max 2

[15]

57. (a) 1. Occurs in an unchanging environment; 1
- +
2. (Initial range of values in which) mean is best adapted;
 3. Selection against extremes / selection for the mean;
 4. Mean/median/mode unaltered
 5. Range/S.D is reduced;
 6. Repeated over many generations;
 7. Increasing proportion of populations becomes well adapted to environment;
- max 4

- (b) Little green light reaches bottom as absorbed by surface dwellers / water;
 Red and blue not absorbed and so penetrate;
 Variation in pigments of sediment dwellers;
 Bacteria with chlorophyll at an advantage;
 As chlorophyll absorbs red and blue;
 (Survive to) reproduce in greater numbers;
 Pass on advantageous alleles/genes in greater numbers / increase in
 frequency of advantageous alleles in subsequent generations;
 Increase in frequency/numbers of bacteria with chlorophyll; max. 6

[11]

60. (a) similar characteristics / physically similar / DNA similar;
 breed among themselves;
 to produce fertile offspring;
 do not share same ecological niche with any other species; max 2

- (b) (i) isolation;
 no gene flow between populations;
 variation;
 different environmental factors;
 natural selection / selection for specific alleles / characteristics;
 change in allele / phenotype frequency;
 changes over a long period of time; max 4

- (b) (ii) more habitats / niches;
 more / greater range of food for herbivores;
 more / greater range of food for carnivores / predators;
 more detritus; max 2

- (c) colonisation / description e.g. seeds blown in / pioneer species;~
 succession;
 alteration of habitat / more humus / deeper soil;
 development of herbaceous / field layer;
 followed by shrub layer; max 4

[12]

61. (a) Do not share same ecological niche/
 do not produce fertile young if crossed/do not interbreed; 1

- (b) (i) magnirostris; 1
 (ii) Four; 1

- (c) Common ancestor varied;
 Due to mutation;
 Differences in local environment/food supply;
 Better adapted varieties survived and reproduced;
 Passing on genes for these characteristics;
 Habitat/behavioural isolation;

max 4

[7]

62. (a) (i) cyanogenic, (ii) non-cyanogenic;
 in (i) both enzymes are present both dominant alleles are present;
 in (ii) enzyme A is absent no formation of cyanogenic
 glucoside/hydrogen cyanide;

3

- (b) (i) gametes of both parents correct AB, Ab, aB, ab:
 genotypes of all offspring correct;
 (ii) 9 cyanogenic:7 non-cyanogenic;

3

- (c) (i) high frequency of dominant alleles at low altitude/low frequency
 of dominant alleles at high altitude/converse for recessive alleles;
 (ii) idea of selection against cyanogenic at high altitude and
 non-cyanogenic at low altitude;
 variation in cyanogenesis is present in population;
 slugs eat more non-cyanogenic plants; freezing injures more
 cyanogenic;
 at low altitude more cyanogenic survive to reproduce/converse at
 high altitude;
 pass alleles on to next generation;
 so higher frequency of dominant alleles in next generation/converse
 at high altitude;

6

[12]

63. (a) (i) maintain form/different phenotypes when grown in same environment;
 (ii) produce fertile offspring;

2

- (b) idea of natural selection against plants with upright form/upright plants fail to
 survive;reason why plants do not survive - plants with upright form fail to
 complete life cycle/out competed by low-growing plants for named
 resource/effect of low temperature/effect of low photosynthesis;

2

- (c) not isolated;
 transfer of genetic material/seeds/pollen between populations/cross
 pollination/cross breeding;
 so each population cannot evolve independently;

2

(d) variation present in the species/large gene pool;
likely that some individuals will have the required characteristics/
alleles for survival, 2

[8]

64. (a) isolated population/group of flies/no gene flow;
variation/mutation (in population);
some able to use new food;
so less competition;
(survive and) reproduce to give new population. max 3

(b) take flies from each population and interbreed;
if no fertile offspring, then different species/ if present,
same species. 2

[5]

65. (a) (i) 3,4,5 (must give all three) 1
(ii) 57 – 59mm 1

(b) larger body has smaller surface area to volume ratio;
reduces heat loss;
OR
larger body has thicker/more fat;
better insulated/ reduces heat loss;
Reject - stay warm 2

(c) mutations/source of inherited variation;
more birds with larger bodies survive and breed;
more chance of alleles/genes (for larger body)being passed on;
frequency of alleles/genes for larger body increases in population; 3

[7]

66. (a) variation between members of population/species;
predation/disease/competition results in differential survival;
some have adaptations that favour survival;
survive to reproduce/have more offspring/ pass on
their alleles/genes;
produces changes in frequency of allele /gene pool/
genotypes/phenotypes; 4 max

- (b) (i) reduces it;
homozygous much more;
correct use of figures, hetero by 29/30% and
homozygous by 92/94%; 2 max
- (ii) people without Hb^C lower survival rate, so less
likely to pass on Hb^A allele;
increasing chance of children where both parents
carry Hb^C;
homozygous Hb^C most likely to survive and pass on allele 2 max

[8]

67. (a) pesticide not biodegradable/broken down;
stored in tissues/fat;
persists in food chain/bioaccumulation/biomagnification;
animals higher up the food chain eating larger numbers of organisms
lower down; 3 max
- (b) mutation produced (allele/gene for) resistance;
(reject mutation as a result of pesticide)
variation within insect population / some insects able to survive application;
reproduce;
pass on alleles/genes; 3
- (c) pesticide is lipid soluble;
membranes contain lipid/phospholipid;
OR
pesticide fits into receptors/proteins on membrane;
passes through carrier proteins/facilitated diffusion /active transport; 2
(points must be linked)

[8]

68. (a) breed together;
if fertile offspring, then same species; 2
- (b) isolation of two populations;
variation already present due to mutations;
different environmental conditions / selection pressures;
selection of different features and hence different alleles;
different frequency of alleles;
separate gene pools / no interbreeding; 4 max

- (c) selection of mate dependent on colour pattern;
prevents interbreeding / keeps gene pools separate; 2

[8]

69. (a) genetic variation/ variation in gene/allele(s) in populations for cyanide production; colder/below 0°C (January) areas, cyanogenic plants die in this cold/acyanogenic survive; non-cyanogenic allele/gene passed on more often/its frequency increases; warmer (January) areas cyanogenic plants at advantage, because of less herbivore selection pressure/feeding; so cyanogenic survive more often to pass on cyanogenic allele/gene. 4 max

- (b) large (and equal) number of quadrats in each area;
(reject several)
random sampling method, described;
(accept described 'systematic' method)
percentage cover/point hits per quadrat/count plants;
mean/average value for each area;
statistics test to see if differences significant. 4 max

[8]

70. (a) (i) Accurate means without error/free from mistakes when callipers used;
Reliable means that figure can be reproduced when measurement Repeated/show little variation about true value; 2

- (ii) If data unreliable, there will be a wide range of values;
Large standard deviation;
The higher the figure on the top line of the equation, the greater
The percentage measurement error; 2 max

- (b) (i) Plot graph of mean skull breadth against mean cranial volume/
scatter diagram;
Draw line of best fit / calculate coefficient of correlation;
Look for figures close to +1 or -1; 2

- (ii) Skull breadth is a linear measurements/can be measured with a single measurement/less prone to error/Cranial volume more difficult to measure because...; 1

- (iii) Could distinguish between large male polecats and small female ferrets;
Little overlap in standard deviations;
Mean measurements for female polecats and male ferrets are very similar; 3
- (c) Scientists could use method suggested/protocol established in earlier paper (thus saving time);
Findings more likely to be reliable if they replicate the findings of others; 2
- (d) Some stomachs may contain more than one type of prey item; 1
- (e) Unidentified bird remains small percentage of total prey/found in few stomachs;
Significant numbers of rabbits/rats eaten and these are pests; 2

[15]