

1. (a) (i) *gene*
length of DNA;
codes for a (specific), polypeptide / protein / RNA; max 1
- allele*
alternative form of a gene;
found at a, locus / particular position on, a chromosome; max 1
- (ii) *assume allele refers to coat colour allele*
(coat colour) gene / alleles, only on X chromosome;
A no (coat colour), gene / allele, on Y chromosome
male cats, XY / only have one X chromosome;
males have only one (coat colour) allele / cannot have two (coat colour) alleles;
need black and orange alleles for tortoiseshell colour; 2
- (b) parental genotypes $C^r C^r \times C^w C^w$;
gametes C^r, C^w ;
F₁ genotypes and phenotypes 1 mark:
 F_1 genotypes (all) $C^r C^w$
 F_1 phenotypes (all) pink;
F₂ genotypes and phenotypes 1 mark:
gametes $C^r, C^w C^r, C^w$;
 F_2 genotypes $C^r C^r C^r C^w C^r C^w C^w C^w$
 F_2 phenotypes red pink (pink) white;
 F_2 ratio 1:2:1;
accept other symbols if key given.
accept r and w as symbols without key. 6
- (c) (i) 65; 130; 65; 3
- (ii) $0.138 + 0.007 + 0.061$; (or other suitable working)
 $0.206 - 0.208$;
2 marks for correct value if no working shown
ecf for both marks but calculated value must be to three decimal places 2
- (iii) support, figure lower than 5.991 / figure lower than critical value;
R 'support' on its own.
ecf applies if value in (ii) is incorrect 1

2. named characteristic;
named environmental factor; (mark first answer only) 2 [2]
3. (a) (i) sympatric; 1
(ii) ranges of two species, overlap/close together/AW;
no geographical barrier;
ref to behavioural/genetic/physiological/prezygotic barrier;
correct ref to named area of map; max 2
- (b) ref to mate selection by size; ie large with large or small with small
ref to monogamy;
ref to intermediate sizes, at disadvantage/selected against/ora;
intermediate do not pass on alleles/ora;
suggested reason why intermediate at disadvantage/ora max 3
- (c) female produces a lot of eggs;
selects male, that can store lots of eggs/has a large pouch/ora;
large males fertilise many eggs/ora;
chance of more offspring surviving;
or
large female and small male produce intermediates/ora;
intermediates at disadvantage/ora; max 2 [8]
4. (i) crossing over; *treat chiasma(ta) as neutral* 1
(ii) prophase; 1
(iii) have different, alleles/base sequence of DNA;
A sister chromatids have same alleles/non sister have different alleles 1 [3]
5. two different genes represented in each gamete ie Q or q and R or r;
four correct combinations ie Q and R, Q and r, q and R, q and r; 2 [2]

6. (i) (parental genotypes:) AaBb × aabb;
 (gametes:) AB, Ab, aB, ab (all) ab;
 (offspring genotypes:) AaBb, Aabb, aaBb, aabb;
 (offspring phenotypes:) grey body/normal wing, grey body/bent wing,
 black body/normal wing, black body/bent wing;
[sequence of phenotypes must match genotypes for mark]
 (phenotypic ratio:) 1 : 1 : 1 : 1;
apply ecf.
accept alternative symbols if a key is given, but if no key given max 4 5
- (ii) 80,80,80,80; 1
- (iii) (working) $0.1125 + 0.3125 + 0.05 + 0.45$;
 $= 0.925$; **A** $0.9/0.92/0.93$
2 marks for correct answer with no working.
ecf if correctly use wrong figures from (ii) 2
- (iv) yes (*but no mark for yes on own*)
 as calculated figure is smaller than 7.82;
ecf applies to value calculated in part (iii) 1
- [9]**
7. deficiency gives resistance to malaria;
 deficient/resistant, individuals more likely to survive;
 alleles, passed to next generation;
 natural selection;
 presence of *Plasmodium* is selection pressure;
 frequency of this allele increases;
 phenotype more common in population;
 AVP; e.g. others more likely to die of malaria 3 max
- [3]**
8. (a) (dominant) epistasis; 1
- (b) ref. frame shift;
 ref. three extra, triplets/amino acids;
 may introduce stop code so shorter, polypeptide/protein;
 may increase length of, polypeptide/protein;
 may alter, shape/3' structure, of, polypeptide/protein;
 affects active site;
 protein/polypeptide, may lose function;
 protein/polypeptide, may have different function; max 4

- (c) (i) *Parental phenotypes: White Leghorn x Red Junglefowl*
Parental genotypes: IICC x iiCC or Iicc x iiCC;
F₁ genotype: IiCC or IiCc; 2
- (ii) 3 white : 1 pigmented *or* 13 white : 3 pigmented; 1

[8]

9. gene bank;
 source of alleles;
 for future (selective) breeding;
 to counteract, genetic erosion/loss of genetic variation;
 to counteract, inbreeding/homozygosity;
 to counteract extinction;
 for changed conditions;
 example of changed conditions; e.g. *climate/environment/disease/fashion*
 to preserve as yet unidentified, alleles/traits; max 4

[4]

10. pigmented birds more likely to be damaged;
 at all percentages;
 more damage as percentage of pigmented birds increases to 23%;
 more damage as percentage of white birds increases to 24%;
 fall in damage of white birds at, 25%/highest percentage; max 3

[3]

11. (i) for benefit of humans;
 to improve, trait(s)/named trait;
 to produce desirable, phenotype/genotype;
 to increase number of desirable alleles;
 to increase homozygosity;
 AVP; max 2

- (ii) ref. self-pollination;
 ref. inbreeding;
 limited gene pool; max 2

- (iii) ref. different numbers of chromosomes;
 hybrid is $3n$;
 sterile;
 gametes have 22 and 11 chromosomes/hybrid has 33 chromosomes;
 some chromosomes unpaired;
 failure of meiosis;
 ref. uneven distribution of chromosomes;
 ref. other barrier to interspecific cross; max 2 [6]
12. stated advantage;
 detail; e.g. *particular character (not whole phenotype)/can alter one trait only (without affecting background genes)/can add allele from different taxon with which breeding may not be possible/quicker (than the many generations of, selective breeding/backcrossing)* 2
- stated disadvantage;
 detail; e.g. *cannot precisely position insert (so) unknown/unanticipated effect/may pass to other species (with unknown/undesirable, effect)/regarded as ethically undesirable (no market/crop destroyed by protesters)/cannot breed from GM (requires cloning)* 2 [4]
13. (i) ✕;
 ✕;
 ✓ (tick);
 ✕; 4
- (ii) discontinuous; [*do not allow if no reason given*] 1
reason
 one, gene/locus; **A** major/Mendelian, gene
 discrete phenotypes/ora;
 qualitative/large effect/little environmental effect; max 1 [6]
14. (i) asexual; **A** binary fission / cloning **ignore** mitosis 1

- (ii) 1 restore diploid number when gametes fuse / AW;
 2 prevents doubling of chromosome number (in each successive generation);
 3 without use of gametes there is less variation;
 4 no input of genetic material from more than one individual;
 5 triploid / $5n$ / etc, would be infertile;
 6 AVP; e.g. polyploid would result in loss of variation
- 2 max
- [3]

15. *chinchilla* – $C^{Ch}C^{Ch}$ $C^{Ch}C^H$ $C^{Ch}C^a$;
agouti – $C^A C^A$ $C^A C^{Ch}$ $C^A C^H$ $C^A C^a$;
- 2
- [2]

16. *max 3 from points 1 to 5*
- 1 limited, food supply / space;
 2 competition;
 3 predation;
 4 disease;
 5 reached carrying capacity / death rate = birth rate;
- marking points 1 – 5 linked to keeping population stable*
- 6 individuals show variation;
 7 variation due to, combination of alleles / mutations;
 8 best adapted survive / ora; **A** *survival of fittest idea*
 9 reproduce;
 10 pass alleles to offspring;
 11 frequency of favourable alleles will, increase / be maintained; **A** ora
- 5 max
- [5]

17. (a) *linkage*
 (two or more) genes / loci, on same chromosome; **R** alleles do not assort independently (in meiosis) / inherited together;
- crossing over*
 reciprocal exchange of portions of, chromatids / DNA; **A** swapping alleles between (paternal and maternal) homologous chromosomes; **A** bivalent in prophase I (of meiosis);
- max 2 max 3

(b) anthers removed (before maturity) (to produce male sterility);
 male sterilisation; *genetic or, PGS / hormone*
 pollen transferred by hand;
 plants isolated;
 flowers bagged (before and after pollination); max 3

(c) (i) **R** 'chance' alone
 chance fertilisation;
 chance re picking 50 offspring;
 chance re other traits affecting survival;
 AVP; e.g. position effect, different gene interactions affecting
 expression,
 effect of crossing over on numbers of other classes max 1

(ii) *award two marks if correct answer (16%) is given without working*
 recognition of recombinant classes;

$$\frac{32}{200} \times 100;$$

$$=16%;$$
 max 2

(iii) 1,2 $\frac{A \quad B}{a \quad b} \times \frac{a \quad b}{a \quad b} \quad ;; \mathbf{A} (AB)(ab) \times (ab)(ab)$
 3 both chromatids per chromosome shown;
 4 crossover shown;
 5 result of crossover shown;
 6 most / 84%, gametes A B and a b [\times a b]; **A** AB and ab
 7 = parental;
 8 few / 16%, gametes A b and a B [\times a b]; **A** Ab and aB
 9 = recombinant;
 10 ref 16 map units apart / close together; max 6

[15]

18. (i) production of desired changes in phenotype of an organism;
 selection of appropriate alleles / AW;
 by artificial selection;
 use as parents / mate, those showing desired phenotype
 (to larger degree); max 2

- (ii) measure of value of individual's genotype (for breeding);
 mate with number of proven individuals;
 assess phenotypes of offspring; **R** genotypes
 average value;
 especially useful for sex-limited traits; **R** sex-linked
 e.g. sex-limited trait; max 4

[6]

19. *description*

- D1 chosen male and female mated;
 D2 ref to desired characteristic / named desired characteristic;
 D3 ref to AI;
 D4 advantage of using AI;
 D5 offspring inspected and best mated;
 D6 several / many, generations;
 D7 ref to problem inbreeding;
 D8 ref to way of minimising inbreeding;
 D9 ref to heritability;
 D10 easier to select for traits with high heritability / ora;
 D11 easier to select for discontinuous variation / ora continuous variation;
 D12 ref to polygenes / additive effect; *max 6 'describe' D marks*

explanation

- E13 selective breeding involves whole genomes;
 E14 hence other traits follow selected trait(s);
 E15 ref to linkage;
 E16 artificial selection;
 E17 selection, different from natural selection / for benefit of humans;
 E18 starter population, small / not representative;
A founder principle *max 4 'explain' E marks*

AVP either D or E mark;

- e.g. ref to use of, IVF / surrogate, with reason
 ref to loss of alleles / genetic erosion

max 8

QWC - legible text with accurate spelling, punctuation and grammar; 1

[9]

- 20.** genetically isolated populations;
 allopatric speciation / AW;
 ref to genetic drift;
 ref to, founder effect / founder population;
 loss of alleles / genetic erosion / reduced gene pool / loss of genetic
 diversity / AW;
 ref to, disease / population crash;
 AVP; e.g. ref to exposure to different selection pressures max 4

[4]

21. (i) semi-conservative replication;
DNA, polymerase / helicase;
breaks hydrogen bonds between two DNA strands / unzips DNA;
each DNA strand acts as a template / both strands copied;
complementary base-pairing (with free DNA nucleotides);
sugar-phosphate backbone forms; 2 max
- (ii) crossing-over;
in prophase;
recombination of, non-sister / maternal and paternal, DNA;
AVP; e.g. matching cuts in DNA
DNA ligase 2 max
- (iii) synapsis / to hold, (homologous) chromosomes / bivalent, together;
(so close enough) for crossing-over;
so can be evenly segregated;
AVP; e.g. to package or support chromosomes,
avoid DNA breaking,
easier to move DNA 2 max
- [6]**
22. (i) **A, B and E** ; 1
- (ii) *apply ora throughout*
produced by, sexual reproduction / fusion of gametes / fertilisation ;
ref to random mating ; *random fertilisation = 2 marks*
contain chromosomes from two individuals / diploid organisms ;
more alleles ; 2 max
- (iii) **C and D** are haploid organisms ;
haploid cells have, one set of chromosomes / half the number of
chromosomes ;
meiosis requires pairing of homologous chromosomes ;
ref to maintaining chromosome number when gametes fuse / gametes
must be haploid ; 2 max
- [5]**

23. marking points 1,6 and 9 must be linked to correct statements as to what is taking place in these stages to gain the mark.

- 1 prophase 1 ;
- 2 synapsis / homologous chromosomes pair up / bivalents form ;
- 3 crossing over ;
- 4 chiasma(ta) occur ;
- 5 DNA / alleles, exchanged ; **A** linked genes separated ;
- 6 metaphase 1 ;
- 7 independent / random, assortment ;
- 8 bivalents line up on equator, independent of each other / randomly ;
- 9 metaphase 2 ;
- 10 independent assortment of chromatids ;
- 11 chromosome mutation ;
- 12 named example ; e.g. non-disjunction
- 13 AVP ; e.g. ref to non-sister / non-identical, chromatids. 7 max

QWC – clear well organised using specialist terms ;

award the QWC mark if four of the following are used in correct context
prophase, metaphase, homologous, bivalent, chiasma, crossing over,
independent assortment

1

[8]

24. parent genotypes baby blood group

 $I^O I^O \times (I^O I^O)$

O ; mark across each line in table

 $I^A I^B \times I^O I^O$

B ; if no marks gained mark down columns

 $I^A I^O / I^A I^A \times I^O I^O$

A ; max 2 marks if baby blood groups correct

 $I^A I^B \times I^A I^O / I^A I^A$

AB ;

[4]

25. (a) (i) epistasis ;
dominant ;
correct ref to epistatic and hypostatic gene ;
ref to protein / enzyme / inhibitor, product of allele A ;
prevents, transcription / translation ;
inhibits, expression / gene action ;
blocks enzyme activity ; 3 max

- (ii) small number of phenotypes ;
distinct (phenotypic) classes ;
qualitative ;
two genes / AW ;
large effect ;
different genes have different effects ;
not environmental ;
AVP ; 3 max

- (b) (i) emasculate /remove stamens from / male sterility gene in, seed parent ;
bag flowers, before / after, pollination ;
grow in isolation ;
transfer pollen by hand ; 2 max
- (ii) increase genetic contribution of that species / *ora* ;
keep (alleles of) background genes of that species ;
so that only A/a exchanged / AW ;
to see effect of A/a in other species ; 2 max
- (iii) to produce, homozygous recessive / aa / AW ;
so that, wanted allele / desired trait, expressed ; 1 max
- (c) pollinators can distinguish colour ;
bees attracted to pink ; [A refs to 'blue' or UV re pink]
swapping alleles reduces visits by normal pollinator ;
swapping alleles attracts wrong pollinator ;
selectively bred / aa / red *M lewisii*, decreases bumblebee visits;
but does not attract many hummingbirds ;
selectively bred / Aa / pink *M. cardinalis*, attracts bumblebees;
and decreases hummingbird visits only slightly ;
ref comparative figures ;
colour important to bees ;
colour not important to hummingbirds / some other feature important
to hummingbirds ;
AVP ; 4 max

[15]

26. more transcription by QQ genotype ;
at both ages ;
in both skeletal and cardiac muscle ;
A 'throughout' / 'in all cases' for 1 mark of these 2
much more in skeletal muscle / slightly more in cardiac muscle ;
in QQ genotypes expression falls with age in both skeletal and cardiac muscle ;
in qq genotypes expression rises with age in skeletal but falls in cardiac muscle ;
use of comparative figures ; 4 max

[4]

27. (a) penetration of biofilm difficult ;
ref to diffusion of antibiotic ;
detail of diffusion ;
larger SA of separate bacteria / *ora* ;
does not reach all bacteria in film / *ora* ;
antibiotic trapped by film ;
detail of entrapment ;
dead bacteria in film form barrier ;
AVP ; e.g. horizontal transmission / conjugation, easier in biofilm
AVP ; 4 max

- (b) both strains have identical sensitivity when in suspension ;
to all three antibiotics ;
both, less sensitive / more resistant, when in biofilms (*ora*) ;
strain 1 much, less sensitive / more resistant ;
comparative figures ;
C most effective / AW ;
B least effective / AW ; 4 max
- (c) mutation ;
random / chance / pre-existing ;
detail of mutation ; e.g. base substitution, addition, deletion
ref to, selection / selective advantage ;
codes for different, glucan / biofilm ;
affects all three antibiotics ;
blocks antibiotic from reaching cells ;
binds antibiotics ; 4 max
- (d) horizontal transmission ;
(copy of) plasmid ;
via conjugation ;
detail ; conjugation tube / 'R' plasmid / single strand DNA transferred
via transformation ;
transferred by (bacterio)phage ; 3 max

[15]

28. (a) *any two of the following*
(monomer) not glucose ;
contains nitrogen ;
contains, sulphur ;
AVP ; R ref to branching 2 max
- (b) amount of glycoprotein varies (in different cells) ;
(cells carry out) endocytosis to different extents ;
cells have different life spans / example ;
no time for polysaccharide to accumulate in short lived cells ;
number / role, of lysosomes not same in all cell types ;
AVP ; 1 max
- (c) *with Hunter's syndrome, lysosomes / vesicles, might be*
larger ;
more numerous ;
have different shape ;
stain differently ;
AVP ; e.g. granular cytoplasm 1 max

- (d) (i) unaffected parents can have an affected child ; *ora*
e.g. 3, 4, 8 / 11, 12, 16, 17 ; 1 max
- (ii) only males affected ; *ora*
mothers pass it on ; *ora*
on the X chromosome ;
carrier women asymptomatic / dominant normal allele masks trait ;
4 / 11 / 1, could be carriers ; 2 max
- (e) there are only 3 cases / too small a sample ;
mostly female line shown ;
AVP ; e.g. pedigree of, 3 / 12, not known
progeny of, 13 / 14 / 15, not known 1 max
- (f) drug must act in all cells ;
lysosomes are within cells ;
hard for drug to reach ;
if drug acts as enzyme, polysaccharide on cell membranes may be broken
down ;
tissue mechanical support would break down ;
AVP ;
AVP ; e.g. no animal model
protein drug digested in gut
rare condition (qualified), economic argument 2 max

[10]

29. (i) Q, S, P, N, M, R ; 1
- (ii) *accept correct names of stages*
Q ; A prophase 1
M ; A anaphase 2
Q / S ; A prophase 1 / metaphase 1
S ; A metaphase 1
R ; A telophase 2 5
- (iii) DNA replication ;
synthesis of proteins / named protein ; A transcription / translation
synthesis of membrane ;
synthesis of, organelle(s) / named organelle ;
respiration ;
AVP ; e.g. centrioles replicate ; 2 max

[8]

30. (i) Individual 2 - X^HY ;
 Individual 5 - X^hY ;
 Individual 6 - X^HY ;
 Individual 9 - X^HX^h ;
max 2 if sex chromosomes not shown 4
- (ii) half / 0.5 / 50% / 1 in 2 ; **A** 1:1, 50:50 **R** 1:2 1
- (iii) carriers have, both / H and h / dominant and recessive, alleles ; **A** are heterozygous **R** two alleles
 females have two X chromosomes / ora ; 2
31. (a) form of a gene ;
 position of, gene / allele on, chromosome / DNA ; 2

[7]

- (b) 1 *Woodland* more, dark / unbanded, snails **or** fewer, light / banded, snails ;
- 2 better camouflaged / ora ;
- 3 against, leaf litter / uniform background ;
- 4 relevant woodland data quote on colour **and** banding ;
- 5 *Grassland* more, yellow / banded, snails **or** fewer, dark / unbanded, snails ;
- 6 better camouflaged / ora ; (*only award if missed point 2*)
- 7 against, pale / yellow / green / variable, background ;
- 8 relevant grassland data quote on colour **and** banding ;
- 9 survivors possess advantageous alleles / ora ;
- 10 reproduce ;
- 11 pass alleles on (to, offspring / next generation) ;
- 12 ref to stabilising selection (in both habitats) ;
- 13 ref to other **named** selection pressure(s) ;
- 14 not a very mobile population *or* little, immigration / emigration ;
- 15 separate gene pools described ;
- 16 little mutation taking place ; **A** no new camouflage method over time
- 17 habitat stable ;
- 18 ref to why unfavourable alleles have not disappeared ;
- 19 AVP ; e.g. calculated average figures for both habitats 8 max
- QWC – clear well organised using specialist terms ;**
- clear and well organised and must include marking points 4 and 8 1

[11]

32. (a) estimate of role of genotype in phenotypic variation / AW ;
 heritability = V_G / V_P ;
 when heritability high much of variation is, genetic / not environmental / ora ;
 high heritability will result in successful selective breeding / ora ; 2 max
- (b) single / major / Mendelian, gene ;
 large effect ;
 little environmental effect ;
 dominant allele T expressed in homo- and heterozygote ;
 not polygenic ;
 not additive ;
 discontinuous variation / not continuous variation ;
 qualitative / not quantitative ; 2 max

- (c) (i) triplet of bases that does not code for an amino acid ;
ATT / ATC / ACT ;
code to mark end of gene ;
code to stop transcription / ref to disengagement RNA polymerase ; 2 max
- (ii) transcription halted early / AW ;
protein will, be smaller / have fewer amino acids ;
tertiary structure / 3D shape different ;
binding / affinity, different ;
protein inactive ; 3 max
ref to *lac* operon ;
- (iii) ref to, promoter / operator / 'on' switch ;
allele T is regulator ;
(protein) binds to DNA ;
(protein) binds to repressor and prevents it binding to DNA ;
allows RNA polymerase to bind ;
AVP ; e.g. enzyme affecting transcription 2 max
- (d) (i) tt + T / AW, increases number of tillers per plant ;
and number of branches per tiller ;
ref to comparative figures ; 2 max
- (ii) inserted into genome randomly / cannot choose where it is inserted ;
may be within a frequently expressed gene ;
may be after an 'on' switch ;
lacks normal controls ;
AVP ; e.g. no other alleles affecting it
different promoter 2 max

[15]

33. 1 both result from changes in allele frequencies ;
2 selective breeding often faster than evolution / ora ;
3 both require selection of parents ;
4 to pass alleles to offspring ;
5 selective breeding involves artificial selection ;
6 v. evolution involves natural selection ;
7 man selective agent in selective breeding ;
8 v. whole environment selective agent in, natural selection / evolution ;
9 selective breeding for benefit of man ;
10 may be detrimental to organism / e.g. detriment ;
11 v. fitness for environment ;
12 single / few, trait(s) in selective breeding ;
13 v. whole, phenotype / genotype ;
14 AVP ;
15 AVP ; 8 max
- QWC – legible text with accurate spelling, punctuation and grammar;** 1

[9]

34. (i) economy of, materials / resources ;

economy of energy ;
saves unnecessary, transcription / translation ; 2 max

- (ii) random / chance / preexisting, mutation (for resistance) ;
resistants survive / susceptibles die ;
natural selection ;
insecticide selective agent ; **A** selective pressure
resistants pass, mutation / allele for resistance, to offspring ; **R** gene
frequency of, mutation / allele for resistance, increases in population ; 5 max

[7]

35. (a) (i) **AaBB** white;
aaBB black;
Aabb white;
aabb brown; 4

(ii) (dominant) epistasis; 1

- (iii) codes for inhibitor;
protein;
blocks transcription (of allele coding for pigment);
ref to, regulator / promoter;
blocks enzyme (producing pigment);
AVP; e.g. detail max 3

- (b) (i) $AaBb \times AaBb / AaBb \times Aabb$;

both must have A because they are white;

* both must, have a / not be homozygous AA, because some
kittens coloured;

* both must have b to give brown kittens;

- '*must be heterozygous at both loci*' = 1 only

at least one / one or both, must have B to give black kittens;

credit ref to Punnett square showing genotypes;

credit ref to Punnett square showing phenotypes; max 5

- (ii) $AaBb \times AaBb$ 12 white : 3 black : 1 brown;;
 $AaBb \times Aabb$ 6 white : 1 black : 1 brown;; max 2

[15]

36. **A** / 'marbling';
 scale 0 – 1;
 measure of genetic v. environmental contribution;
 high value most easily selected for;
 value <0.02 results in no selective breeding;
 ease of selection = 'marbling' > growth rate > subcutaneous fat > 'rib eye';
 all the traits / even 'rib eye', can be selected for; max 3
- [3]**
37. increase in use of, GM crop / GE crop / Bt cotton;
 no / less, insecticide needed;
 reduced number of cases of pesticide poisoning;
 ref to figures (e.g. by $\times 4.4$);
 reduced cost (insecticide);
 ref to figures (e.g. by $0.62 \text{ US\$ kg}^{-1} / \times 1.38$);
 ref to limitations of survey;
 AVP;
A reverse arguments max 4
- [4]**
38. (a) 1 : 2 : 1; 1
- (b) **1** ref to, codominant / equally dominant (alleles);
A incomplete dominance but **R** genes as alternative to alleles
- 2** appropriate symbols for two codominant alleles; eg G^1 and G^2
R a capital and a lower case symbol or two different letters
 such as G and Y
- 3** parent plant shown or stated to be heterozygous; **A** if it is explained
 that any sunny plant is heterozygous
- 4** gamete genotypes shown appropriately;
- 5** correct offspring genotypes;
- 6** the 'Sunny' / yellow-green, were heterozygous / genotype shown
 by diagram;
- 7** the dark green / the yellow, were homozygous / genotype shown
 by diagram; max 5

- (c) **1** ref to, randomness / chance (sampling);
2 ref to random fertilisation;
3 totals are (quite) a large sample, pot **B** / single pot / six, is a small sample;
4 if (only) six seeds, there is a greater chance of departing from an expected ratio / AW;
5 probability of six seedlings all the same is $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$;
6 with, many seedlings / the totals, the deviations of the individual results cancel out;
7 some departure from an expected ratio is always likely / idea;
8 only the yellow number (33) deviates from the expected / 28 is half 56;
9 chi squared test could be used;
10 AVP; max 3

- (d) *credit ora here*
A chloroplast as alternative to chlorophyll
 yellow seedlings have, no / very little, chlorophyll;
 cannot photosynthesise;
 die when, energy reserve / carbohydrate (accept food), in seed is exhausted;
 dark green grow more because they have more chlorophyll
 (than the yellow-green);
 so dark green have more, photosynthetic products / named product;
 ref to competition between the seedlings;
 ref to, selection / selective advantage; max 3

[12]

- 39.** *parental genotypes* RrBb × Rrbb;
gametes RB Rb rB rb Rb rb;
offspring genotypes RRBb RrBb (RrBb) Rrbb RRbb (Rrbb) rrBb rrb;
offspring phenotypes rough black rough white smooth black smooth white;
expected ratio 3 : 3 : 1 : 1;
accept correct gametes, offspring genotypes and offspring phenotypes in Punnett square
*use ecf except for ratio **Reject** the ratio 6 : 6 : 2 : 2*
ratio not a stand alone mark – there must be some correct working to support it

[5]

40. (i) length of DNA;
codes for a (specific), polypeptide / protein / RNA;
found at a, locus / particular position on, a chromosome; 2
variety / form of a gene; **R** type of gene **A** type of a gene 1
- (ii) *assume the allele = coat colour allele*
(coat colour) gene / alleles, only on X chromosome;
A no (coat colour), gene / allele, on Y chromosome
male cats, XY / only have one X chromosome;
(males have) only one (coat colour) allele / cannot have two
(coat colour) alleles;
need black and orange alleles for tortoiseshell colour; max 2
41. (a) $R^R R^R$ - low, do not have enough vitamin K in diet / ref to figures;
 $R^R R^S$ - high, (warfarin resistant) and have enough vitamin K
/ ref to figures;
 $R^S R^S$ - low, will be killed by warfarin / ref to effects of warfarin;
If quote probabilities for survival less than 50% is low and over 50% is high 3
- (b) (i) mutation / named mutation;
change in DNA base sequence; max 1
- (ii) variation within population;
some individuals produce enzyme not susceptible to warfarin;
these individuals survive / selective advantage;
reproduce / breed;
pass, resistance / advantageous allele, to offspring; **R** gene
those without resistance die;
ref to selective pressure of warfarin; max 5
- (c) does not directly involve humans;
environment selects individuals that will reproduce; max 1
- (d) resistant allele / R^R , will decrease **and**, susceptible allele / R^S , will
increase;
 $R^R R^R$ at a disadvantage due to vitamin K requirements / $R^S R^S$ at
an advantage due to warfarin being removed;
A frequencies of both alleles will stay the same;
must be linked to second statement
no longer any selective pressure / no directional selection; max 2

[5]

[12]

42. (a) (i) Aabb - pink;
aaBB - green; 2
- (ii) (dominant) epistasis;
ref to, epistatic / hypostatic, gene;
ref to, promoter / gene switching;
increased, transcription / expression; max 3
AVP; enzyme to alter pigment / change structure of pigment /
make more pigment / complementary action
- (b) (i) *parents* (AaBb) red spines × (aabb) green spines;
gametes AB Ab aB ab × ab; **A** from Punnett square
offspring genotypes;; *minus 1 for each of first two mistakes*
phenotypes related to genotypes; **A** key
ratio 1 red spines : 1 pink spines : 2 green spines; max 5
- | | | | | |
|----------------|-------------------|--------------------|---------------------|---------------------|
| <i>gametes</i> | <i>AB</i> | <i>Ab</i> | <i>aB</i> | <i>ab</i> |
| <i>ab</i> | <i>AaBb</i> | <i>Aabb</i> | <i>aaBb</i> | <i>aabb</i> |
| | <i>red spines</i> | <i>pink spines</i> | <i>green spines</i> | <i>green spines</i> |
- (ii) many AaBb and aabb;
ref 1 : 1 ratio of these;
ref linkage;
ref parental types;

few Aabb and aaBb;
ref 1 : 1 ratio of these;
ref recombinants;
ref crossing over;

many red and green spined;
few / no, pink spined;
1 : 1 green : red / more green than red;
ref proportions depend on how close, loci / genes, are; max 5

[15]

43. (i) mutation;
chance / random / preexisting;
insecticide acts as selective, agent / pressure;
susceptibles die / resistants survive;
resistants pass, mutation / allele, to offspring; **A** gene max 3
- (ii) mosquito is vector; **A** carrier
obligatory / AW;
part of life cycle is in mosquito;
not killed by insecticide; max 2

[5]