

4.3 GENETIC DIVERSITY VIA MUTATION AND MEIOSIS (2) – MARK SCHEMES

Q1.

- (a) Chromosomes attach to equator / middle of cell / spindle;
Prophase;
Anaphase;
DNA replication / synthesis / chromosome copying / duplication;
Telophase; 5
- (b) (i) Meiosis; 1
- (ii) 32; 1

[7]

Q2.

- (a) 1. Homologous chromosomes pair up / bivalents form;
2. Crossing over / chiasmata form;
3. Produces new combination of **alleles**;
4. Chromosomes separate;
5. At random;
6. Produces varying combinations of chromosomes / genes / alleles (*not twice*);
7. Chromatids separated at meiosis II / later;
Independent assortment / random segregation = marking points 4 and 5

6 max

- (b) (i)
- | | | | |
|---------------------|--------------|-------------|---|
| Parental phenotypes | Agouti | White | |
| Parental genotypes | BbAa | bbaa | ; |
| Gamete genotypes | BA Ba bA ba | ba | ; |
| Offspring genotypes | BbAa Bbaa | bbAa bbaa | ; |
| Offspring phenotype | Agouti Black | White White | ; |

*Phenotypes must match genotypes
Allow marking points 2 and 3 if correctly derived from wrong parental genotypes*

4

- (ii)

Colour of offspring	Observed (O)	Expected (E)	(O-E)	(O-E) ²	$\frac{(O-E)^2}{E}$
Agouti	34	30	4	16	0.53

Black	35	30	5	25	0.83
White	51	60	9	81	1.35
					$\frac{(O-E)^2}{E} = 2.71 \text{ or } 2.72$

∴ 2

(χ^2 correct = 2 marks)

((O-E)² all correct = 1 mark)

p = 0.05;

2 degrees of freedom;

Differences due to chance / no significant difference as χ^2 less than / to left of critical value OR Not due to chance / difference is significant as χ^2 greater than to right of critical value;

(as appropriate for candidates χ^2)

3

[15]

Q3.

- (a)
1. Chromosomes shorten / thicken / condense;
 2. Chromosomes associate in homologous / (described) pairs / formation of bivalents / tetrads;
 3. Crossing-over / chiasma formation;
 4. Join to spindle (fibres) / moved by spindle;(*)
 5. (At) equator / middle of cell;(*)
 6. (join via) centromere / kinetochore;(*)
 7. (Homologous) chromosomes move to opposite poles / chromosomes separate / move apart; (ALLOW 'are pulled apart')
 8. (Pairs of) chromatids separated in 2nd division;

(*) OR "independent assortment"
unqualified = 1 mark

max 6

- (b)
1. Crossing-over; [IGNORE any wrong ref. to timing]
 2. Independent / random assortment / orientation / segregation of (homologous) chromosomes in meiosis I;
 3. Independent / random assortment / orientation / segregation of chromatids in meiosis II;

+ Any three from:

4. Different adaptations / some better adapted;
5. Some survive / example described;
6. To reproduce;
7. Pass on gene / allele;
8. Allows for changing environment / different environment / example described;

max 5

- (c) (i) 21;

1

- (ii)
1. *T. aestivum* has 2 copies of each type of chromosome / is diploid;
 2. *T. aestivum*'s chromosomes can form bivalents / can assort in meiosis / can produce haploid gametes;

3. *T. aestivum*'s gametes receive a copy of every chromosome / receive all the genetic information;

ACCEPT converse argument for hybrid plants

3

[15]

Q4.

- (a) Later fertilisation / cell fusion; (NOT just 'sexual reproduction')
Restoring diploid / original number / not doubling chromosome number;

ALLOW ref '½ + ½'

2

- (b) Any three pairs from:

need comparison of meiosis and mitosis each time

Meiosis	Mitosis
(Homologous) chromosomes associate in pairs	(Homologues) independent / do not pair (IGNORE ref. separation)
Crossing-over / chiasmata formation	No crossing-over;
Two / (nuclear stages) divisions / → 4 offspring cells	One / (nuclear stage) division / → 2 offspring cells;
<u>Genetically</u> different (product)	Genetically identical (product);

IGNORE refs. To location

max 3

[5]

Q5.

- (a) Isolation / quarantine / 'kept separate';

Screening / testing (of patients / doctors etc);

Sterilisation of wards / equipment / method to improve hygiene;

Do not allow improve 'hygiene' or 'cleanliness' without named example such as 'washing hands' use of gloves etc.

2 max

- (b) May not all be absorbed;

May be broken down / metabolised / excreted quickly;

To kill the microorganisms / bacteria;

Reference to antibiotic resistance;

Reference to becoming 'immune' negates last marking point.

2 max

- (c) (i) P;

1

- (ii) S;

1

- (d) (i) Prevents bias;
 Vested interest (of scientists);
 Prevents 'placebo' / positive / negative / psychological effects / 'demand characteristics' (in volunteers);
- 2 max
- (ii) Age;
 Ethnicity;
 Lifestyle;
 Body mass;
 Health;
 Sex of person;
Ignore references to same or different
- 2 max
- (e) Gradual / slight increase followed by rapid / greater increase;
Allow more detailed descriptions which describe similar trend of gradual increase followed by rapid increase.

1

[11]

Q6.

- (a) Cannot make (active) enzyme A (which converts precursor to linamarin) / cannot make linamarin;
- 1
- (b) (i) **AL + AI + 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" but cancel if reference to crossing-over
- 2
- (c) From parental genotypes: **AaLI** × **AaLI** (no mark)
 Note: If wrong parental genotypes / wrong gametes: ALLOW correct derivation of offspring genotypes = 1 max

Correct derivation of offspring genotypes; max 2 marks if error in Punnett square

	AL	AI	aL	al
AL	AALL	AALI	AaLL	AaLI
AI	AALI	AAll	AaLI	Aall
aL	AaLL	AaLI	aaLL	aaLI

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

- 3
- (d) (i) There was no (significant) difference in damage between cyanogenic and acyanogenic / 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
- (e) High slug population:
1. Find only 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 on plants from slugs / no selective advantage / no selection / described; 4

[15]

Q7.

- (a) Chromosomes: **C = 8 and D = 4;**
 DNA: **C = 300 and D = 150;** 2
- (b) (i) testis / ovary;
accept anther / carpel / stamen / testicle 1
- (ii) to make chromosomes / chromatids / DNA / genetic material visible; 1

[4]

Q8.

- (a) (i) Faster / greater / more effective response in children;
Do not accept children have more haemoglobin 1
- (ii) Use line of best fit; 1
- Extrapolate / extend line (and read from graph);
*Allow calculation using rate of increase per day = one mark.
 However for both marks this must be linked to line of best fit.* 1
- (iii) More than one polypeptide chain;
Allow many polypeptide chains.

'Haemoglobin has four polypeptide chains' must be in correct context to gain mark.

1

- (b) (i) Has same water potential;

Allow converse for effect of using distilled water or a concentrated solution.

1

No (net) water movement / osmosis;

1

Cells will not swell / burst / change size;

No osmotic lysis = two marks

1

- (ii) Pernicious anaemia (cells) greater range / spread / variation of diameters / widths;

Some pernicious anaemia (cells) wider than 9 (μm) / some less than 5.5 (μm) / without pernicious anaemia none more than 9 (μm) / none less than 5.5 (μm);

Pernicious anaemia (cells) peak / most frequent at 8.5 (μm) / peak / most frequent at higher diameter / / without pernicious anaemia peak / most frequent at 7 (μm) / peaks at lower diameter;

There are several alternatives for marking points 2 and 3

2 max

[9]

Q9.

- (a) group of organisms with similar features;
can (interbreed to) produce fertile offspring;

2

- (b) directional selection;
any TWO from
selection against one extreme / for one extreme;
against broadest beaks in B and narrowest beaks in A / for narrowest in B and broadest in A;
whole distribution / range / mean / mode / median is shifted towards favoured extreme;

3 max

[5]

Q10.

- (a) Interphase / S-phase;

1

- (b) **A D C E B**;

1

- (c) Attachment of centromeres / chromosomes / chromatids; Separation of centromeres / chromatids / chromosomes;

2

- (d) Halves chromosome number / haploid;

Diploid / full number restored at fertilisation;
Allow correct reference to variation

max 2

[6]

Q11.

- (a) Excitation of chlorophyll molecule / electrons / energy of (pairs of) electrons raised to higher energy level;

Electron(s) emitted from chlorophyll molecule;

Electron(s) to electron transport chain;

Loss of energy by electron(s) along electron transport chain;

Energy lost by electron(s) is used to synthesise ATP;

From ADP + Pi;

“By electrons” need not be stated in each marking point if it can be reasonably inferred that the candidate is referring to electrons

max 5

- (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 and 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;

6

[11]

Q12.

- (a) (meiosis) anaphase I;
chromosomes are moving apart;
chromosomes still double structures;

3

- (b) chromosomes in each (homologous) pair twist around each other;
chromatids break and rejoin to chromatid on sister chromosome;

(accept points from a suitable diagram)

2

[5]

Q13.

- (a) (i) Continuous variation – range of values / not discrete categories / many categories / no gaps;

1

- (ii) Crossing over / chiasmata;
Random segregation / independent assortment;
In meiosis I and meiosis II;

max 2

- (b) Range influenced by single 'outlier' (*accept anomaly*) /
 converse for S.D.;
 S.D. shows dispersion / spread about mean / range only shows highest
 and lowest values / extremes;
 Or
 S.D. allows statistical use;
 Tests whether or not differences are significant;

max 2

[4]

Q14.

- (a) replication / duplication / doubling of chromosomes /
 replication of DNA / transcription of DNA;
- (b) (i) cell to show correct number of chromosomes;
 correct shape and position of centromere;
- (ii) as (i) except everything halved – *Ignore crossing over*;
 (if mitosis and meiosis reversed, allow 1 if otherwise correct)
- (c) to replace cells;

1

2

2

1

[6]

Q15.

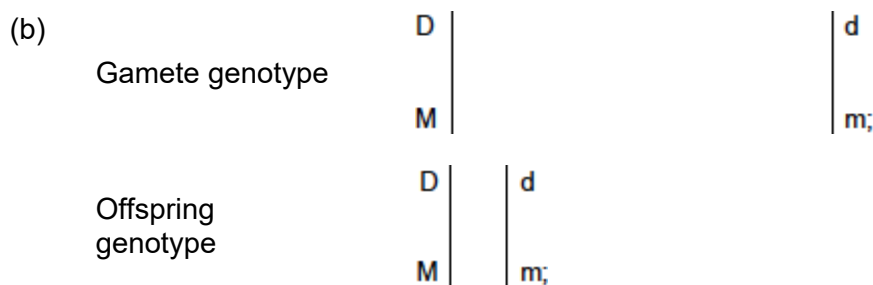
- (a) *Two linked points:*

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



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

3

[5]

Q16.

- (a) (i) join / attach nucleotides, to form a strand / along backbone / phosphodiester

	bonds; (<i>reject reference to H bonds, complementary base pairing</i>)	1
(ii)	ribosome / RER;	1
(b) (i)	CGTTACCAA;	1
(ii)	CGU UAC CAA;	1
(c)	<u>substitution</u> ;	1
(d) (i)	alanine;	1
(ii)	(mutation 1) no change(to sequence of amino acids); codon for alanine / degenerate codon / same amino acid coded for;	2
	(mutation 2) (change in sequence) <u>valine</u> replaced by <u>alanine</u> / codon for <u>alanine</u> ; folding / shape / tertiary structure / position of bonds may change; (<i>reject peptide bonds</i>)	2
		[10]

Q17.

(a)	haploid cells produced / halves chromosome number; fertilisation / fusion of gametes, <u>diploid</u> number restored; chromosome number constant at each generation;	2 max
(b)	principle of 2 chromosomes per cell; 4 correct combinations, long with short;	2
(c) (i)	8;	
(ii)	8;	2
(d)	(in males) more gametes produced / rapid gamete production / more lost;	1
		[7]

Q18.

(a) (i)	TB Tb tB tb;	1
(ii)	homologous chromosomes appropriately labelled;	1
(iii)	separation of chromatids;	1

- (b) (i) crossing over occurs;
between **D** and **G**;
sections of chromatids / chromosomes / DNA / genes exchanged; 3
- (ii) crossing over is infrequent(between close genes); 1

[7]

Q19.

- (a) high energy radiation / ionising particles;
named particles / α , β , γ ;
colchicine;
x rays / cosmic rays;
uv (light);
carcinogen / named carcinogen;
mustard gas / phenols / tar (qualified); 1 max

- (b) (i) removal of one or more bases / nucleotide;
frameshift / (from point of mutation) base sequence change; 2

- (ii) sequence of bases in mRNA would change;
(sequence of) amino acids different / different primary structure;
(active site / enzyme 1) changed tertiary shape / changed active sites;
white pigment does not bind;
lilac pigment not produced / white pigment remains unchanged /
enzyme 1 does not function; 4 max

- (iii) blue and lilac; white;

<i>colour of petal</i>
<i>(white)</i>
blue
lilac;
white;

2

[9]

Q20.

- (a) different form of a gene; 1

- (b) hydrogen bonds broken;
semi-conservative replication / both strands used (as templates);
nucleotides line up complementary / specific base pairing / A and T / C and G;
DNA polymerase; 4

- (c) deletion causes frame shift / alters base sequence (from point of mutation);

changes many amino acids / sequence of amino acids (from this point);
substitution alters one codon / triplet / one amino acid altered / code
degenerate / same amino acid coded for;

3

[8]

Q21.

- (a) (i) 8 'chromatids' each side;
spindle drawn;
- (ii) 4 chromosomes;
1 from each homologous pair;
- (b) produces haploid cells / chromosome number halved;
fertilisation maintains the diploid / chromosome number (in next generation);

2

2

2

[6]

Q22.

(a)

A | | A
b | | b

a | | a
B | | B

1

(b) bivalent;

1

(c) (i) Ab, aB;

(ii) AB, ab;

2

(d) mutation;
different / new allele formed / genes deleted or duplicated / sequence
of genes changed (*reject genetic information*);
random fusion of gametes / fertilisation;
new combination of alleles;
independent assortment (of chromosomes) (*accept random*);
shuffling of maternal and paternal chromosomes / new combination
of alleles;
(*ignore references to stages of meiosis*)
any 2 × 2

4 max

[8]

Q23.

(a) 6;

1

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

2 max

(ii) separation / splitting / 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]

Q24.

- (a) sections of chromatids exchanged;
sections have different alleles;
new combinations of (linked) alleles;
(allow 1 mark for idea that 'genes' are exchanged, if no other marks gained)

3

- (b) (i) length controlled by many genes / polygenes;
each gene may have different alleles / idea of additive effects;
OR
environmental factors / or named factor;
how named factor may affect growth of seeds;

2 max

- (ii) 1. selection of large seeds for sowing;
2. higher proportion of alleles for long length / loss of alleles for short seeds from population;
3. (possible appearance of) new alleles through mutation;
4. process repeated over many generations;
(G - allow 1 mark idea for that 'largeness' selected, survives and inherited)

4

[9]

QWC 1

Q25.

- (a) to get haploid / n / half number of chromosomes (in cells);
so that each cell gets one copy of each chromosome / gene / full set of genes / so that fertilisation produces diploid / constant chromosome number; results in independent assortment;

2

- (b) (i) 4;

1

- (ii) meiosis (has halved the chromosome number);

1

- (ii) (mitosis because) zygote gets two chromosomes from each gamete / has four chromosomes;

accept haploid for two and diploid for four

gamete-producing plant has two chromosomes,
so mitosis to produce gametes with two;

2

[6]

Q26.

- (a) limited genetic diversity in modern varieties / greater genetic diversity in old varieties / older varieties contain other (useful) alleles / genes;
old varieties useful for future breeding programmes;

2

- (b) (i) seeds lose viability / will not germinate / develop after long storage;

1

- (ii) preserve variety of alleles / different genotypes / maintain genetic variation;
prevent inbreeding / reduces the chance of homozygosity;

2

[5]

Q27.

- (a) meiosis halves the chromosome number / from diploid to haploid / produces haploid / n cells;
when gametes fuse / at fertilisation, the diploid number is restored / this keeps the chromosome number constant / correct from one generation to the next / after sexual reproduction;
introduces genetic variation / independent assortment / crossing over;

3

- (b) **M** between moss plant and spore;

1

[4]

Q28.

- (a) mutation changes the amino acid sequence / primary structure of Factor VIII protein;
changes the tertiary structure / 3D shape;

2

- (b) (mutant) Factor VIII protein is non-functional / does not work with Factor IX;
so no conversion of Factor X to active form and pathway blocked;

2

- (c) boy's blood contains (active) Factor VIII;
Factor VIII haemophiliac's blood contains (active) Factor IX;
the mixture has both Factors and so the pathway can complete / blood clots;

2 max

[6]