1 Genetics

1.1 The contribution of Gregor Mendel to the science of genetics

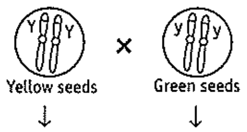
1 (a) Self-pollination in pea plants often results in the offspring having the same heredity as the parents. Mendel 'selfed' many of his plants in experiments where large numbers of plants were allowed to 'self-pollinate', e.g. Tt × Tt; RrYy × RrYy. Also, self-pollination tends to reduce the chances of unwanted fertilisation from 'foreign' pollen.
(b) The fact that each pea plant characteristic was determined by a single pair of genes (rather than a multiple allele set), allowed Mendel to notice simple patterns of heredity.

2 (a) By carrying out controlled, artificial cross-pollinations (removing anthers from flowers; dusting pollen onto female parts; covering the flowers with muslin bags), Mendel was able to carry out the crosses he wanted.
(b) Mendel started his experiment with plants whose heredity was known and pure. This was necessary before predictions of dominance or phenotypic ratios could be made. Trying to establish inheritance patterns from impure strains would have been impossible.
(c) A large sample size and repetition of experiments provide more valid results for interpretation than do small sample size and single experiments.
(d) Mendel counted offspring and calculated ratios and was able to use this mathematical information to determine general principles of inheritance.

3 Genes.

4 (a) (i) Tall. (ii) Yellow. (iii) Round. (iv) Coloured. (v) Axial. (vi) Inflated. (vii) Green.
(b) The characteristic that appeared exclusively in the F_1 plants was Mendel's 'dominant' character.
(c) (i) 2.84:1. (ii) 3.01:1. (iii) 2.96:1. (iv) 3.15:1.
(v) 3.14:1. (vi) 2.95:1. (vii) 2.82:1.
(d) The larger the sample size of F_2 plants counted, the closer the ratio to the expected '3:1'.

5 (a) As for diagram B — for example:



↓ ↓
… and so on

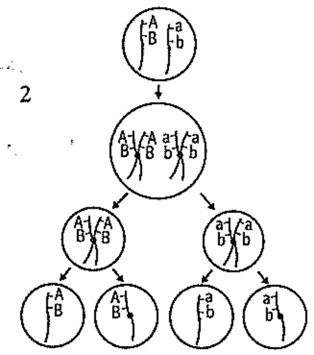
(b) As for diagram C — for example:

YY × yy
↓
… and so on

1.2 Meiosis (sex cell formation) and genetics

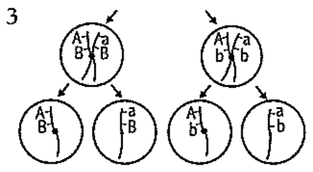
1 (a) Body cell from individual with genetic make-up 'Aa'.
(b) Meiosis.
(c) First meiotic division.
(d) Second meiotic division.
(e) Two types of sex cell are produced — 'A' and 'a'.

2



Sex cells: 'AB' and 'ab' (two types)

3



Sex cells: 'AB', 'aB', 'Ab' and 'ab' (four types)

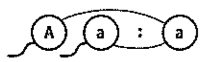
4 Sex cells: four types of sperm: RY; Ry; rY; ry;
four types of eggs: RY; Ry; rY; ry.

F_2:				
	RRYY	RRYy	RrYY	RrYy
	RrYy	RRyy	RrYy	Rryy
	RrYY	RrYy	rrYY	rrYy
	RrYy	Rryy	rrYy	rryy

Phenotypes:	Round yellow	:	Round green	:	Wrinkled yellow	:	Wrinkled green
Ratio:	9	:	3	:	3	:	1

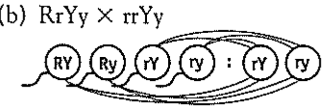
5 (a) T; t. (b) T. (c) UB; Ub. (d) UB; Ub; uB; ub. (e) TY; tY.

6 (a) Aa × aa



Aa:aa

(b) RrYy × rrYy



or construct a Punnett square.

RrYY RrYy rrYY rrYy
RrYy Rryy rrYy rryy

7 Crossing over increases the genetic variety (number of different types) of sex cells.

8 (a) Greater (four types of sex cell in pea plants versus two types of sex cell with linked genes and no crossing over).
(b) The same (both produced identical sets of four sex cells).

1.3 Monohybrid cross genetics: single gene inheritance

1 (a) TT:Tt; all tall. (b) Tt:tt; 50% tall:50% dwarf. (c) TT:Tt:Tt:tt; 75% tall:25% dwarf.
2 (a) 0%. (b) 50%. (c) 25%. (d) 100%.
3 (a) Man: BB; woman: bb; children: Bb. (b) Man: bb; woman: Bb ; child: bb. (c) 50%.
4 (a) Ll × Ll. (b) $\frac{2}{3}$ (66.7%).
5 (a) BB:Bb:Bb:bb; black:white = 3:1. (b) Bb:bb; black:white = 1:1.

1.4 Dihybrid cross genetics

1 (a) Tall round:tall wrinkled:dwarf round:dwarf wrinkled — in a ratio of 9:3:3:1.
(b) Tall wrinkled:dwarf wrinkled — in the ratio of 1:1.
(c) Tall round:dwarf round:tall wrinkled:dwarf wrinkled — in a ratio of 1:1:1:1.
(d) All tall round.

2 (a) All rough black.
(b) Rough black:rough white:smooth black:smooth white — in the ratio of 9:3:3:1.
(c) All rough black.
(d) Rough black:smooth black:smooth white — in the ratio of 2:1:1.

3 (a) Hairless long wing:hairy long wing:hairless vestigial wing:hairy vestigial wing — in a ratio of 1:1:1:1.
(b) All long-winged hairless.
(c) Long-winged hairless:long-winged hairy:vestigial winged hairless:vestigial winged hairy — in a ratio of 9:3:3:1.
(d) Long-winged hairless:long-winged hairy — in a ratio of 1:1.

4 (a) 25%. (b) 100%. (c) 56%. (d) 50%.

5 Short green:short striped:long green:long striped — in a ratio of 1:1:1:1.

1.5 Incomplete dominance

1 (a) Red:pink — 1:1. (b) Pink:white — 1:1. (c) All pink. (d) Red:pink:white — 1:2:1.
2 By crossing red with white-flowered plants. 3 (a) 100%. (b) 50%. (c) 50%. (d) 50%.
4 (a) BB × Bb. (b) BB × bb. (c) BB × Bb; Bb × Bb; Bb × bb. (d) Bb × Bb.

1.6 Sex-linked inheritance

1 (a) 0%. (b) 0%. (c) 25%. (d) 50%. 2 (a) Normal (carrier) ♀ : normal ♂ in the ratio 1:1. (b) 25%.
3 25%. 4 (a) (i) X^BY^-. (ii) X^bY^-. (iii) X^BX^B. (iv) X^bX^b. (v) X^BX^b.
(b) No, because in order to be tortoiseshell an individual must carry the 'B' and 'b' gene on the X-chromosomes. Since females are the only ones to possess two X-chromosomes, they are the only tortoiseshell cats.
(c) (i) 50%. (ii) 50%. (iii) 25%. (iv) 25%.

1.7 Genetics and pedigree charts

1 (a) 1 = aa; 2 = Aa; 3 = Aa; 4 = Aa; 5 = AA or Aa.
(b) (i) If albinism were dominant, there is no way that two recessive individuals (individual 4 and his partner) could produce a dominant character in one of their offspring. Therefore albinism must be a recessive character.
(ii) If albinism were sex-linked, males would be mainly affected. This is not the case, therefore albinism is not sex-linked.

2 (a) I1: X^CY^-; I2: X^CX^c; I3: X^CY^- ; I4: X^CX^c.
II1: X^CX^c; II2: X^CY^-; II3: X^cY^-; II4: X^CX^c.
III1: X^CX^c or X^CX^C; III2: X^cY^-; III3: X^CY^-; III4: X^cX^c.
(b) (i) Normal ♀:normal (carrier) ♀:normal ♂:colour-blind ♂: 1:1:1:1.
(ii) Carrier ♀: colour-blind ♀: normal ♂: colour-blind ♂: 1:1:1:1.
(iii) Colour-blind ♀: colour-blind ♂: 1:1.
(c) First cousins.

3 (a) (i) If the condition (near-sightedness) were dominant, then individuals I1 and her partner would be recessive individuals (aa). Under this assumption there is no way that they could produce an affected child. Since they do produce an affected child, then the condition must be recessive.
(ii) If the condition were sex-linked, mostly males would be affected. Since mostly females are affected, the condition is not sex-linked.
(b) 1 = Mm; 2 = Mm; 3 = MM or Mm; 4 = Mm; 5 = mm; 6 = Mm; 7 = Mm; 8 = mm. (c) (i) 25%. (ii) 50%.

1.8 The combined effect of genotype and environment on phenotype

1 Differences in light, soil or humidity conditions.
2 When an environmental factor switches on a gene, a certain phenotype caused by that gene is expressed. Environmental factors can also switch off a gene causing the phenotype not to be expressed.
3 Diet; emotional environment; exposure to the elements (e.g. sun).
4 (a) Diet; radiation; stress; exposure to certain chemicals. (b) Diet; smoking; stress. 5 Answer subject to student opinion.

1.9 DNA structure and replication

1 Adenine, thymine, guanine, cytosine. 2 Adenine–thymine; guanine–cytosine.
3 (a) At the start of mitosis and meiosis, single-stranded chromosomes duplicate (or replicate) to become two identical strands (i.e. a double-stranded chromosome). Without DNA replication this would not be possible.
(b) Without DNA replication at the start of mitosis, daughter cells would only have one half of the required chromosome number.
(c) Meiosis would produce only two daughter cells instead of four. (Also, there would only be one division of meiosis instead of two; no crossing over between homologous double-stranded chromosomes.)
4 Left-hand strand (top to bottom): C, T, A, A, G, C. Right-hand strand (top to bottom): G, A, T, T, C, G.
5 The critical finding was the discovery that adenine always paired with thymine and guanine always paired with cytosine.
6 (a) A 'blueprint' is an architect's building plan.
(b) On a 'blueprint' all building instructions and information are given for the construction of a building. Within the 'DNA blueprint' all the instructions and information are provided for the development and functioning of an organism.
7 The ability of DNA to make copies of itself is the basis of all reproduction of life on earth.