Principles of Inheritance and Variation

Standard difficulty · 20 questions · 40 marks · Time: 38 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. Mendel worked on the garden pea, Pisum sativum, between:
(a) 1800 and 1810 **(b)** 1950 and 1960 **(c)** 1900 and 1910 **(d)** 1856 and 1863

2. In pea, round seeds (R) are dominant over wrinkled seeds (r). In the cross rr × Rr, the fraction of offspring with round seeds is:
(a) 1/2 **(b)** 1/4 **(c)** 3/4 **(d)** 0

3. In the cross AaIi × AAii, the probability of an offspring with genotype AAIi is:
(a) 1/4 **(b)** 1/16 **(c)** 1/2 **(d)** 1/8

4. Parents with genotypes I^AI^A and ii have a child. The probability that the child has blood group O is:
(a) 3/4 **(b)** 1/4 **(c)** 0 **(d)** 1/2

5. Colour blindness is X-linked recessive. A carrier woman marries an affected man. The probability that a daughter is a carrier is:
(a) 0 **(b)** 1/2 **(c)** 1/4 **(d)** 1

6. Sickle-cell anaemia is caused by:
(a) an autosomal recessive gene (Glu → Val at the sixth position of β-globin)
(b) an autosomal recessive gene (too little globin made)
(c) trisomy of chromosome 21 (47 chromosomes)
(d) an autosomal recessive gene (no enzyme to convert phenylalanine to tyrosine)

7. A test cross of a dihybrid gives 400 offspring, of which 160 show recombinant combinations. The distance between the two genes is:
(a) 80 map units **(b)** 60 map units **(c)** 40 map units **(d)** 20 map units

8. Assertion (A): A pea plant with yellow seeds, crossed with one with green seeds, gives only offspring with yellow seeds if it is heterozygous (Yy).
Reason (R): In a test cross, a heterozygote gives two kinds of gametes in equal numbers.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer 8 × 2 = 16 marks

9. State Mendel's law of segregation.

10. A pea plant pure for violet flowers and tall stems (VVTT) is crossed with one pure for white flowers and dwarf stems. The F1 is selfed and gives 480 F2 plants. How many of each phenotype are expected?

11. A plant with inflated pods and axial flowers, of genotype IIAa, is test-crossed with a plant with constricted pods and terminal flowers. What offspring are expected, and in what ratio?

12. A man of blood group A (I^Ai) marries a woman of blood group O (ii). What blood groups can their children have, and with what probabilities?

13. A woman with normal vision whose father had colour blindness marries a man with colour blindness. What fraction of their sons and of their daughters are expected to have colour blindness, and what fraction of the daughters are carriers?

14. An individual is heterozygous at 4 independent genes and homozygous at two others. How many kinds of gametes can it form? If two such individuals are crossed, how many genotypes and (with complete dominance) phenotypes appear in the offspring?

15. In snapdragon, red (RR) × white (rr) gives pink F1 plants. If the F1 is selfed and gives 152 plants, how many of each colour are expected? Why is the ratio different from Mendel's?

16. What is the mechanism of sex determination in honeybee and in Drosophila? How many chromosomes do male and female honeybees have?

Section C — Word problems — 4 × 4 = 16 marks

17. Explain a monohybrid cross with the example of tall and dwarf pea plants.

18. Cross a pea plant pure for axial flowers and wrinkled seeds with one pure for terminal flowers and round seeds. Give the genotypes of the parents and the F1, the gametes of the F1, and the phenotypic ratio and numbers expected among 128 F2 plants. Which law does this show?

19. Three linked genes give these recombination frequencies: F–E 18%, E–D 5%, F–D 23%. Find the order of the genes and draw the map in words.

20. A carrier woman for colour blindness marries a normal man. (a) What fraction of their sons and daughters are affected or carriers? (b) One of their daughters, whose status is unknown, marries a normal man. What is the chance that a daughter of hers is a carrier?

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Answer key

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Q	Answer	Working
1	**(d) 1856 and 1863**	—
2	**(a) 1/2**	gametes r × R, r
3	**(c) 1/2**	P(AA) × P(Ii) = 1/2 × 1
4	**(c) 0**	children: A 1
5	**(b) 1/2**	a daughter gets one X from each parent
6	**(a) an autosomal recessive gene (Glu → Val at the sixth position of β-globin)**	—
7	**(c) 40 map units**	recombination frequency = 160 ÷ 400 × 100 = 40%
8	**(d) A is false, but R is true.**	A is false: Yy × yy gives Yy and yy in a 1 : 1 ratio. R is true.
9	**The two alleles of a gene, present together in an individual, separate (segregate) during gamete formation, so each gamete gets only one of them.**	—
10	**violet flowers, tall stems: 270; violet flowers, dwarf stems: 90; white flowers, tall stems: 90; white flowers, dwarf stems: 30**	9 : 3 : 3 : 1
11	**inflated pods, axial flowers; inflated pods, terminal flowers in the ratio 1 : 1**	gametes of IIAa: 2 kinds in equal numbers
12	**A: 1/2; O: 1/2**	I^A and I^B are codominant; i is recessive
13	**sons: 1/2; daughters: 1/2 affected, 1/2 carriers**	her father gave her his affected X, so she is a carrier; a son gets his X from his mother; a daughter gets one X from each parent
14	**16 gametes; 81 genotypes; 16 phenotypes**	2^4, 3^4 and 2^4; homozygous genes add no variety
15	**red 38, pink 76, white 38; incomplete dominance makes the heterozygote look different, so the phenotypic ratio equals the genotypic ratio 1 : 2 : 1**	—
16	**honeybee: haplodiploidy (males develop from unfertilised eggs); males 16 (haploid), females 32 (diploid); Drosophila: XX–XY (male heterogametic)**	—
17	**TT (tall) × tt (dwarf) gives Tt F1 plants, all tall. Selfing the F1 (Tt × Tt) gives TT, Tt and tt in the ratio 1 : 2 : 1, i.e. 3 tall : 1 dwarf. This shows dominance (T masks t) and segregation (the two**	—

Q	Answer	Working
	alleles separate in gametes and recombine at fertilisation).	
18	**Parents AArr × aaRR; F1 AaRr (axial flowers, round seeds); gametes AR, Ar, aR, ar; F2 axial flowers round seeds 72 : axial flowers wrinkled seeds 24 : terminal flowers round seeds 24 : terminal flowers wrinkled seeds 8 (9 : 3 : 3 : 1); the law of independent assortment**	—
19	**F — E — D: E is in the middle, 18 map units from F and 5 from D (F to D = 23)**	the largest frequency is between the two outer genes
20	**(a) sons: 1/2 affected, 1/2 normal; daughters: none affected, 1/2 carriers; (b) 1/2 × 0 + 1/2 × 1/2 = 1/4**	the daughter is a carrier with probability 1/2 and normal with probability 1/2