



## Principles of Inheritance and Variation — NEET (UG) Pattern Chapter Test

FREE CHAPTER TEST · BIOLOGY · PATTERN OF NEET (UG)

| DURATION   | MAXIMUM MARKS | QUESTIONS | NAME / ROLL NO. |
|------------|---------------|-----------|-----------------|
| 30 minutes | 120           | 30        |                 |

### GENERAL INSTRUCTIONS

1. This question paper has THIRTY (30) multiple-choice questions. All questions are compulsory.
2. Each question has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Marking scheme: +4 for a correct answer, -1 for an incorrect answer, 0 if the question is not attempted.
4. Use of a calculator, log tables or any other aid is not allowed.
5. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 30 minutes before you look at them.

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**Topics covered:** Mendel's laws of inheritance · Deviations from Mendelism · Polygenic inheritance · Chromosomal theory and linkage · Sex determination · Mutation · Pedigree analysis · Mendelian disorders · Chromosomal disorders

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**BIOLOGY (Q1–30) · Multiple choice · +4 / 0 / –1**

Each question has FOUR options. ONLY ONE of them is correct.

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1. In a cross  $AaBbCc \times AaBbCc$ , the three genes assort independently and each shows complete dominance. The proportion of the offspring that show the dominant phenotype for exactly two of the three traits is

- (1)  $9/64$
- (2)  $1/64$
- (3)  $3/64$
- (4)  $27/64$

2. In a cross  $AaBbCcDd \times AaBbCcDd$ , the four genes assort independently. The proportion of the offspring with the genotype  $AaBBccDd$  is

- (1)  $1/256$
- (2)  $1/64$
- (3)  $1/128$
- (4)  $1/32$

3. In snapdragon (*Antirrhinum*), a pure red-flowered plant ( $RR$ ) is crossed with a pure white-flowered plant ( $rr$ ) and all the  $F_1$  plants have pink flowers. An  $F_1$  plant is then crossed with a white-flowered plant. The offspring are

- (1) 1 pink : 1 white
- (2) 1 red : 1 white
- (3) 1 red : 2 pink : 1 white
- (4) all pink

4. A man of blood group A and a woman of blood group B have a child of blood group O. The probability that their next child will have blood group AB is

- (1)  $1/2$
- (2) zero
- (3)  $1/4$
- (4)  $3/4$

5. A man of blood group AB marries a woman of blood group O. The probability that a child of theirs has the same blood group as one of the parents is

- (1) zero
- (2)  $1/2$
- (3)  $1/4$
- (4) 1

6. Suppose human skin colour is controlled by three genes, A, B and C, whose dominant alleles each add equally to the darkness of the skin (additive effect). In a marriage between two persons of genotype  $AaBbCc$ , the proportion of children having exactly three dominant alleles is

- (1)  $1/64$
- (2)  $6/64$
- (3)  $20/64$
- (4)  $15/64$

7. A plant heterozygous for two genes, with the dominant alleles A and B received from one parent and a and b from the other, is test-crossed with aabb. The offspring are: 420 AaBb, 380 aabb, 105 Aabb and 95 aaBb. The distance between the two genes on the chromosome is

- (1) 80 cM
- (2) 10 cM
- (3) 40 cM
- (4) 20 cM

8. Three genes A, B and C lie on the same chromosome. The recombination frequencies between them are: A and B, 12%; B and C, 7%; A and C, 19%. The correct order of the genes is that

- (1) A is between B and C
- (2) B is between A and C
- (3) C is between A and B
- (4) the genes cannot be on one chromosome

9. A woman with normal colour vision, whose father was colour blind, marries a man with normal colour vision. Among their children, the proportion of sons who are colour blind and the proportion of daughters who are carriers are, respectively

- (1)  $\frac{1}{4}$  and  $\frac{1}{4}$
- (2) all and none
- (3)  $\frac{1}{2}$  and  $\frac{1}{2}$
- (4)  $\frac{1}{2}$  and none

10. A woman who is a carrier of haemophilia marries a haemophilic man. The probability that their first child is a haemophilic daughter is

- (1)  $\frac{1}{4}$
- (2)  $\frac{1}{2}$
- (3)  $\frac{1}{8}$
- (4) zero

11. In humans, a child is equally likely to be a boy or a girl. For a couple with three children, the probability that two of the children are girls and one is a boy, in any order, is

- (1)  $\frac{1}{8}$
- (2)  $\frac{3}{8}$
- (3)  $\frac{1}{2}$
- (4)  $\frac{1}{4}$

12. A plant heterozygous for three independently assorting genes (AaBbCc) is crossed with a plant recessive for all three (aabbcc). The proportion of the offspring that resemble the aabbcc parent in all three traits is

- (1)  $\frac{1}{64}$
- (2)  $\frac{1}{27}$
- (3)  $\frac{1}{16}$
- (4)  $\frac{1}{8}$

**13.** Phenylketonuria is inherited as an autosomal recessive trait. Two parents with a normal phenotype have a child with phenylketonuria. The probability that each of their next two children has a normal phenotype is

- (1)  $3/4$
- (2)  $9/16$
- (3)  $1/16$
- (4)  $3/16$

**14.** A woman with normal blood clotting, whose parents are unaffected but whose brother has haemophilia, marries a man who does not have haemophilia. The probability that their first son has haemophilia is

- (1)  $1/2$
- (2)  $1/8$
- (3) zero
- (4)  $1/4$

**15.** In a body cell of a person with Down's syndrome, the number of autosomes is

- (1) 44
- (2) 46
- (3) 45
- (4) 47

**16.** Two parents who do not show a trait have a daughter who shows it. Assuming no new mutation, the trait is inherited as

- (1) autosomal recessive
- (2) autosomal dominant
- (3) X-linked recessive
- (4) Y-linked

**17.** In a cross  $AaBb \times Aabb$ , the two genes assort independently. The fraction of the offspring that are homozygous at both loci is

- (1)  $1/8$
- (2)  $1/2$
- (3)  $3/8$
- (4)  $1/4$

**18.** In the  $F_2$  generation of a dihybrid cross  $AaBb \times AaBb$  with independent assortment, the proportion of the offspring that are heterozygous at exactly one of the two loci is

- (1)  $1/4$
- (2)  $3/8$
- (3)  $1/2$
- (4)  $1/16$

**19.** Genes A and B are 10 map units apart on the same chromosome. A plant that received AB from one parent and ab from the other is test-crossed with aabb. The proportion of offspring of genotype Aabb is

- (1) 10%
- (2) 5%
- (3) 45%
- (4) 25%

**20.** The codon UGG codes for tryptophan. Of the nine possible single-base substitutions in this codon, the number that change it into a stop codon is

- (1) 2
- (2) 1
- (3) 3
- (4) 0

**21.** A diploid plant species has  $2n = 14$ . The numbers of chromosomes in a trisomic, a monosomic and a triploid plant of this species are, respectively

- (1) 15, 13 and 21
- (2) 15, 13 and 42
- (3) 21, 7 and 15
- (4) 16, 12 and 21

**22.** Albinism is an autosomal recessive trait. Two parents with normal pigmentation are both heterozygous for it. The probability that exactly two of their three children are albino is

- (1)  $3/64$
- (2)  $9/64$
- (3)  $27/64$
- (4)  $1/16$

**23.** Two parents are both carriers of an autosomal recessive disorder. One of their children has a normal phenotype. The probability that this child is a carrier is

- (1)  $1/4$
- (2)  $1/2$
- (3)  $3/4$
- (4)  $2/3$

**24.** A man of blood group A who is Rh-positive has genotype  $I^A i Rr$ ; his wife, of blood group B and Rh-negative, has genotype  $I^B i rr$ . The two genes assort independently. The probability that their child has blood group O and is Rh-negative is

- (1)  $1/4$
- (2)  $1/16$
- (3)  $1/8$
- (4)  $3/8$

25. In Mendel's dihybrid cross between pea plants with round yellow seeds (RRYY) and wrinkled green seeds (rryy), what fraction of the  $F_2$  plants with round yellow seeds are true-breeding?
- (1)  $1/16$
  - (2)  $9/16$
  - (3)  $1/9$
  - (4)  $4/9$
26. Which one of the following pairs of contrasting traits was NOT among the seven pairs studied by Mendel in the garden pea?
- (1) Leaf shape (broad / narrow)
  - (2) Pod colour (green / yellow)
  - (3) Flower position (axial / terminal)
  - (4) Seed shape (round / wrinkled)
27. Genes A and B are 20 map units apart. A plant that received Ab from one parent and aB from the other is test-crossed with aabb. The proportion of offspring of genotype AaBb is
- (1) 40%
  - (2) 10%
  - (3) 20%
  - (4) 5%
28. Kernel colour in a cereal is controlled by two genes, A and B, whose dominant alleles each add equally to the redness of the kernel. In a cross  $AaBb \times AaBb$ , the proportion of the offspring with exactly two dominant alleles (an intermediate colour) is
- (1)  $1/16$
  - (2)  $4/16$
  - (3)  $9/16$
  - (4)  $6/16$
29. In snapdragon, flower colour shows incomplete dominance (RR red, Rr pink, rr white), while for height the allele T (tall) is completely dominant over t (dwarf). The two genes assort independently. In a cross  $RrTt \times RrTt$ , the proportion of offspring that are pink-flowered and tall is
- (1)  $9/16$
  - (2)  $3/8$
  - (3)  $3/16$
  - (4)  $1/4$
30. A colour-blind man marries a woman who is homozygous for normal colour vision. Their daughters all marry men with normal colour vision. The proportion of the daughters' sons who are colour blind is
- (1) none
  - (2) all
  - (3)  $1/4$
  - (4)  $1/2$

**END OF THE QUESTION PAPER**

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**ANSWER KEY**

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| Q1  | Q2  | Q3  | Q4  | Q5  | Q6  | Q7  | Q8  | Q9  | Q10 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| (4) | (2) | (1) | (3) | (1) | (3) | (4) | (2) | (3) | (1) |
| Q11 | Q12 | Q13 | Q14 | Q15 | Q16 | Q17 | Q18 | Q19 | Q20 |
| (2) | (4) | (2) | (4) | (3) | (1) | (4) | (3) | (2) | (1) |
| Q21 | Q22 | Q23 | Q24 | Q25 | Q26 | Q27 | Q28 | Q29 | Q30 |
| (1) | (2) | (4) | (3) | (3) | (1) | (2) | (4) | (2) | (4) |

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**WORKED SOLUTIONS**

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**Q1. Answer (4).** For each gene,  $Aa \times Aa$  gives the dominant phenotype with probability  $3/4$  and the recessive with  $1/4$ .

Exactly two dominant traits: choose which two (3 ways)  $\times (3/4)^2 \times (1/4) = 3 \times 9/64 = 27/64$ .  $9/64$  is the proportion for one particular pair of traits only.

**Q2. Answer (2).** Take each gene separately:  $Aa \times Aa$  gives  $Aa$  with probability  $1/2$ ,  $BB$  with  $1/4$ ,  $cc$  with  $1/4$  and  $Dd$  with  $1/2$ . Independent assortment lets us multiply:  $1/2 \times 1/4 \times 1/4 \times 1/2 = 1/64$ .  $1/256$  treats every genotype as  $1/4$ .

**Q3. Answer (1).** Flower colour shows incomplete dominance:  $Rr$  is pink.  $Rr \times rr$  gives  $Rr$  (pink) and  $rr$  (white) in equal numbers,  $1 : 1$ .  $1 \text{ red} : 2 \text{ pink} : 1 \text{ white}$  is the  $F_2$  ratio ( $Rr \times Rr$ ).

**Q4. Answer (3).** An O child is  $ii$ , so each parent carries  $i$ : the man is  $I^A i$  and the woman  $I^B i$ .  $I^A i \times I^B i$  gives  $I^A I^B$ ,  $I^A i$ ,  $I^B i$  and  $ii$  with probability  $1/4$  each, so the chance of an AB child is  $1/4$  (each birth is independent).

**Q5. Answer (1).** The father ( $I^A I^B$ ) passes on  $I^A$  or  $I^B$  and the mother ( $ii$ ) passes on  $i$ , so every child is  $I^A i$  (group A) or  $I^B i$  (group B). No child can be AB, which needs both  $I^A$  and  $I^B$ , or O, which needs  $i$  from both parents. So the probability is zero.

**Q6. Answer (3).** Each parent passes on 3 alleles, so a child receives 6 alleles, each dominant with probability  $1/2$  independently.  $P(\text{exactly 3 dominant}) = C(6, 3)/2^6 = 20/64$ . These children have the intermediate skin colour, which is the commonest class;  $1/64$  is for 6 (or 0) dominant alleles.

**Q7. Answer (4).** The parental combinations (AB and ab) are the largest classes; the recombinants are Aabb and aaBb:  $105 + 95 = 200$  out of 1000, a recombination frequency of 20%, i.e. 20 map units (centimorgans). 80 cM uses the parental classes.

**Q8. Answer (2).** Map distances add along the chromosome:  $12 + 7 = 19$ , the A–C distance. So A and C are the two outer genes and B lies between them (A —12— B —7— C).

**Q9. Answer (3).** Her father gave her his X carrying the colour-blindness allele, so she is a carrier,  $X^c X$ . Sons get their X from her: half are  $X^c Y$  (colour blind). Daughters get the father's normal X and one of hers: half are  $X^c X$  (carriers), half  $XX$ ; none is colour blind.  $1/4$  and  $1/4$  are fractions of all the children, not of sons and of daughters.

**Q10. Answer (1).** Mother  $X^h X$ , father  $X^h Y$ . A daughter receives the father's  $X^h$  for certain and the mother's  $X^h$  with probability  $1/2$ , so half the daughters are haemophilic.  $P(\text{daughter}) \times P(\text{haemophilic} | \text{daughter}) = 1/2 \times 1/2 = 1/4$ .  $1/2$  is the chance for a daughter, once it is known the child is a girl.

**Q11. Answer (2).** Each child's sex is decided independently by the sperm (X or Y, equally likely).  $P(2 \text{ girls and 1 boy}) = C(3, 2) \times (1/2)^3 = 3/8$ .  $1/8$  is for one particular order, such as girl, girl, boy.

**Q12. Answer (4).** This is a test cross: the aabbcc parent gives only abc gametes, so each offspring shows the traits of the gamete from the AaBbCc parent. That parent makes  $2^3 = 8$  kinds of gamete in equal numbers, one of which is abc. So  $1/8$  of the offspring are aabbcc.  $1/64$  is the answer for  $AaBbCc \times AaBbCc$ .

**Q13. Answer (2).** An affected child (aa) shows that both normal parents are carriers (Aa). Each child is then normal with probability  $3/4$ , independently:  $(3/4)^2 = 9/16$ .  $3/4$  is for one child only.

**Q14. Answer (4).** The brother got his  $X^h$  from his mother (the father is unaffected), so the mother is a carrier. Her daughter, the woman, received this  $X^h$  with probability  $1/2$ . If she is a carrier, each son has haemophilia with probability  $1/2$ . So  $P = 1/2 \times 1/2 = 1/4$ .  $1/2$  assumes the woman is certainly a carrier.

**Q15. Answer (3).** Down's syndrome is trisomy of chromosome 21: the cell has 47 chromosomes, of which 2 are sex chromosomes (XX or XY) and 45 are autosomes ( $44 + 1$  extra chromosome 21). 47 is the total number of chromosomes.

**Q16. Answer (1).** Unaffected parents with an affected child means the trait is recessive and both parents are carriers. It cannot be X-linked recessive: an affected daughter ( $X^aX^a$ ) needs an  $X^a$  from her father, who would then be affected. A dominant trait needs an affected parent, and a Y-linked trait cannot occur in a daughter.

**Q17. Answer (4).**  $Aa \times Aa$  gives a homozygote (AA or aa) with probability  $1/2$ ;  $Bb \times bb$  gives bb with probability  $1/2$  (and Bb otherwise). Homozygous at both:  $1/2 \times 1/2 = 1/4$ .

**Q18. Answer (3).** At each locus the offspring is heterozygous with probability  $1/2$  and homozygous with probability  $1/2$ . Exactly one heterozygous locus:  $2 \times (1/2 \times 1/2) = 1/2$  (8 of the 16 squares).  $1/4$  is for being heterozygous at both loci.

**Q19. Answer (2).** 10 map units means 10% of the gametes are recombinant, shared equally between the two recombinant types Ab and aB: 5% each. In a test cross each gamete type gives one offspring class, so Aabb is 5%. 45% is each parental class.

**Q20. Answer (1).** The stop codons are UAA, UAG and UGA. Changing the second base G to A gives UAG, and changing the third base G to A gives UGA. UAA would need two changes. So 2 of the 9 substitutions produce a stop codon (nonsense mutations).

**Q21. Answer (1).**  $n = 7$ . A trisomic has one extra chromosome ( $2n + 1 = 15$ ), a monosomic lacks one ( $2n - 1 = 13$ ), and a triploid has three whole sets ( $3n = 21$ ). 42 is  $6n$ ; 16 and 12 are  $2n \pm 2$  (tetrasomic and nullisomic).

**Q22. Answer (2).** Each child is albino with probability  $1/4$ , independently.  $P(\text{exactly 2 of 3}) = C(3, 2) \times (1/4)^2 \times (3/4) = 3 \times 3/64 = 9/64$ .  $3/64$  forgets that the unaffected child can be any one of the three.

**Q23. Answer (4).**  $Aa \times Aa$  gives  $AA : Aa : aa = 1 : 2 : 1$ . A child with a normal phenotype is AA or Aa, which occur in the ratio  $1 : 2$ , so the chance that it is a carrier is  $2/3$ .  $1/2$  is the chance for a child whose phenotype is not known.

**Q24. Answer (3).** Group O (ii) needs i from each parent:  $1/2 \times 1/2 = 1/4$ . Rh-negative (rr) from  $Rr \times rr$ :  $1/2$ . Together:  $1/4 \times 1/2 = 1/8$ .

**Q25. Answer (3).** 9 of the 16  $F_2$  combinations are round yellow ( $R_Y$ ). Only one of them, RRY<sub>Y</sub>, is homozygous at both loci and breeds true. So  $1/9$  of the round yellow plants are true-breeding;  $1/16$  is the fraction of all  $F_2$  plants, and  $4/9$  are RrYy.

**Q26. Answer (1).** Mendel's seven characters were stem height, flower colour, flower position, pod shape, pod colour, seed shape and seed colour. Leaf shape was not one of them.

**Q27. Answer (2).** Here the parental (non-recombinant) gametes are Ab and aB, 40% each. AB is a recombinant gamete; the 20% recombinants are shared equally between AB and ab, so AB gametes, and AaBb offspring, are 10%. 40% would be right if the plant had received AB and ab from its parents.

**Q28. Answer (4).** A child receives four alleles, each dominant with probability  $1/2$ :  $P(\text{exactly 2}) = C(4, 2)/2^4 = 6/16$  (AAbb, aaBB and AaBb, in  $1 + 1 + 4$  of the 16 squares).  $9/16$  is the  $A_B$  class, which counts dominant phenotypes, not dominant alleles.

**Q29. Answer (2).** Pink (Rr) from  $Rr \times Rr$ :  $1/2$ . Tall (TT or Tt) from  $Tt \times Tt$ :  $3/4$ . Together:  $1/2 \times 3/4 = 3/8$ .  $9/16$  treats colour as completely dominant too.

**Q30. Answer (4).** The man passes his  $X^c$  to every daughter, so all the daughters are carriers ( $X^cX$ ) and none is colour blind. A carrier passes  $X^c$  to half her sons, whatever her husband's genotype, so half of the grandsons through the daughters are colour

blind. Their own sons, who receive the father's Y, are all normal.

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