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Mendelian Genetics

Study Guide — Mendelian Genetics

Pre-med style practice questions on Mendelian inheritance, segregation, independent assortment, pedigrees, and probability

22 items — Study Guide with Answers

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1 **In Mendelian genetics, which statement best distinguishes genotype from phenotype for a simple trait with complete dominance?**

A Genotype describes the observable characteristics; phenotype describes the alleles present.

B **Genotype describes the alleles present; phenotype describes the observable characteristics.** ✓

C Genotype is determined only by the environment; phenotype is determined only by genes.

D Genotype and phenotype are synonymous terms in Mendelian genetics.

E Genotype refers only to recessive alleles; phenotype refers only to dominant alleles.

▶ **Explanation:** Genotype is the genetic makeup (alleles present), while phenotype is the observable trait, which is influenced by genotype and sometimes the environment.

2 **In peas, tall (T) is completely dominant to dwarf (t). Which pair of genotypes produces the same phenotype but different genotypes?**

A TT and tt

B **TT and Tt** ✓

C Tt and tt

D TT and TT

E Tt and Tt

▶ **Explanation:** Both TT and Tt give the tall phenotype under complete dominance, but only TT is homozygous; Tt is heterozygous.

3 **Which description best states Mendel's law of segregation?**

A Different genes sort independently into gametes.

B Each individual carries only one allele for each gene at all times.

C Each gamete receives one allele of each gene because the two alleles separate during gamete formation. ✓

D Alleles are destroyed if they are recessive.

E Only dominant alleles are transmitted to offspring.

▶ **Explanation:** The law of segregation states that the two alleles of a gene in a diploid individual separate during gamete formation, so each gamete carries only one allele.

4 Which statement best describes Mendel's law of independent assortment for two genes on different chromosome pairs?

A Alleles for one gene determine which alleles of another gene are inherited.

B Each pair of homologous chromosomes lines up and separates independently of other pairs during meiosis I. ✓

C All genes assort together as a single unit from each parent.

D Independent assortment applies only to genes on the same chromosome.

E Independent assortment requires that crossing over never occurs.

▶ **Explanation:** Genes on different chromosome pairs assort independently because each homologous pair aligns and separates randomly relative to others at metaphase I.

5 In peas, purple flowers (P) are dominant to white (p). Two heterozygous plants (Pp × Pp) are crossed. What phenotypic ratio of purple to white flowers is expected in their offspring, assuming complete dominance?

A 1 purple : 3 white

B 3 purple : 1 white ✓

C 1 purple : 1 white

D All purple

E All white

▶ **Explanation:** The genotypes from Pp × Pp are 1 PP : 2 Pp : 1 pp, giving 3 purple (PP or Pp) to 1 white (pp).

6 **In the cross Pp × Pp described above, what is the probability that a randomly chosen offspring will be heterozygous (Pp)?**

A 1/4

B **1/2** ✓

C 3/4

D 1/3

E 2/3

▶ **Explanation:** The genotypes appear in a 1 PP : 2 Pp : 1 pp ratio, so 2 out of 4 (1/2) offspring are heterozygous.

7 **A plant shows the dominant phenotype for seed shape (round, R), but its genotype is unknown (RR or Rr). It is crossed with a homozygous recessive wrinkled plant (rr). Half of the offspring are round and half are wrinkled. What is the genotype of the unknown parent?**

A RR

B **Rr** ✓

C rr

D Cannot be determined from this cross

E RR or Rr are equally likely

▶ **Explanation:** An RR × rr cross gives all round offspring. A 1:1 round:wrinkled ratio indicates the unknown parent must be Rr (a classic test cross).

8 **In Mendel's experiments, a 'true-breeding' line for a trait (such as round seeds) is best described genetically as:**

A Heterozygous for the trait

B **Homozygous for the allele controlling the trait** ✓

C Carrying no alleles for the trait

D Carrying both dominant and recessive alleles for the trait

E Having a different genotype every generation

▶ **Explanation:** True-breeding lines consistently produce offspring with the same phenotype when selfed, which occurs when they are homozygous.

9 **A red-flowered plant (RR) is crossed with a white-flowered plant (WW). All F1 offspring are pink (RW). When two F1 plants are crossed, the F2 generation shows red, pink, and white flowers in a 1:2:1 ratio. Which type of inheritance best explains these results?**

A Complete dominance of R over W

B **Incomplete dominance** ✓

C Codominance

D X-linked dominance

E Autosomal recessive inheritance

▶ **Explanation:** In incomplete dominance, heterozygotes (RW) show an intermediate phenotype (pink), and both genotype and phenotype follow a 1:2:1 ratio in the F2.

10 **Which example best illustrates codominance in human genetics?**

A A cross between red and white snapdragons producing pink flowers in all F1 offspring

B A person with genotype IAi having blood group A

C **A person with genotype IAIB expressing both A and B antigens in the AB blood group** ✓

D A person with genotype ii having blood group O

E The dominance of brown eye colour over blue eye colour

▶ **Explanation:** In blood group AB (genotype IAIB), both A and B alleles are fully expressed in the phenotype, which is codominance.

11 **Two individuals with genotype AaBb are crossed. The two genes assort independently and show complete dominance (A over a, B over b). What phenotypic ratio is expected in the offspring?**

A 3:1

B 1:2:1

C **9:3:3:1** ✓

D 1:1:1:1

E 2:1:1:0

▶ **Explanation:** A classic dihybrid cross AaBb × AaBb gives four phenotypic classes in a 9:3:3:1 ratio if the genes assort independently and show complete dominance.

12 **In the AaBb × AaBb cross described above (independent assortment, complete dominance), what is the probability that an offspring will show both dominant phenotypes (A_ B_)?**

A 1/16

B 3/16

C **9/16** ✓

D 1/4

E 3/4

▶ **Explanation:** For each gene, the dominant phenotype appears with probability 3/4. Using the product rule: $(3/4) \times (3/4) = 9/16$.

13 **A man with blood group A and genotype IAi has a child with a woman of blood group B and genotype IBi. Which ABO blood groups are possible in their children?**

A Only A and B

B Only AB and O

C A, B, and AB only

D **A, B, AB, and O** ✓

E Only O

▶ **Explanation:** Gametes are IA or i from the father and IB or i from the mother. Possible zygotes: IAIB (AB), IAi (A), IBi (B), and ii (O).

14 **A woman is a carrier for an X-linked recessive disorder (genotype X^A X^{a}). Her partner is unaffected (X^A Y). They are expecting a son. What is the probability that this son will have the disorder?**

A 0

B 1/4

C **1/2** ✓

D 3/4

E 1

▶ **Explanation:** A son receives Y from the father and either X^A or X^a from the mother with equal probability. If he inherits X^a he will be affected, so P(affected son) = 1/2.

15 **Which pedigree pattern most strongly suggests an X-linked recessive disorder rather than an autosomal recessive one?**

A Trait affects males and females equally in large numbers; unaffected parents can have affected sons or daughters.

B Trait appears in every generation and is equally common in males and females.

C **Trait appears almost exclusively in males; affected fathers do not pass the trait directly to their sons, but all daughters of affected fathers are carriers.** ✓

D Trait only appears in females; affected mothers pass it to all children.

E Trait appears only in one generation and then disappears completely.

▶ **Explanation:** In X-linked recessive inheritance, males are affected more often, affected fathers cannot pass the trait to sons (they pass Y), and all their daughters inherit the mutant X and are usually carriers.

16 **In an autosomal dominant disorder with complete penetrance, which observation in a large pedigree is most consistent with this mode of inheritance?**

A Trait often skips generations; unaffected parents have affected children.

B **Trait appears in every generation, and each affected person has at least one affected parent.** ✓

C Trait affects only males and is passed from affected fathers to all sons.

D Trait affects only females and never appears in males.

E Trait appears only in siblings of affected individuals, never in their offspring.

▶ **Explanation:** Autosomal dominant traits typically show vertical transmission: affected individuals usually have affected parents, and unaffected individuals do not transmit the trait.

17 **A rare autosomal recessive disease is caused by genotype aa. Two unaffected parents have an affected child. Assuming the disease is truly rare in the population and the parents are not related, what are the most likely genotypes of the parents?**

A AA and aa

B AA and AA

C **Aa and Aa** ✓

D aa and aa

E AA and Aa

▶ **Explanation:** For an autosomal recessive disease, affected offspring (aa) from unaffected parents implies both parents are carriers (Aa $\times$ Aa $\rightarrow$ 1/4 aa).

18 **In the family described above (Aa $\times$ Aa parents, autosomal recessive aa disease), an unaffected sibling of the affected child is born. What is the probability that this unaffected sibling is a carrier (Aa)?**

A 1/4

B 1/2

C **2/3** ✓

D 3/4

E 1

▶ **Explanation:** Genotypes from Aa × Aa are 1 AA : 2 Aa : 1 aa. Given the sibling is unaffected, they are either AA or Aa (3 possibilities: 1 AA, 2 Aa). So P(Aa | unaffected) = 2/3.

19 **Two carriers of a rare autosomal recessive disease (Aa × Aa) plan to have three children. Assuming independent outcomes for each child, what is the probability that exactly two of the three children will be affected (aa)?**

A 1/64

B 3/64

C **9/64** ✓

D 27/64

E 1/16

▶ **Explanation:** Each child has probability p = 1/4 of being aa. Using the binomial formula: P(2 affected of 3) = $C(3,2)(1/4)^2(3/4)^1 = 3 \times (1/16) \times (3/4) = 9/64$.

20 **In a cross between two plants that are each AaBb for two genes affecting flower colour, the F2 phenotypes appear in a 9 coloured : 7 white ratio instead of the expected 9:3:3:1. Which genetic explanation best fits this observation?**

A Simple independent assortment with complete dominance at both loci

B Incomplete dominance at both loci

C **Complementary gene action (recessive epistasis), where both dominant alleles A and B are required for colour** ✓

D X-linked inheritance of both genes

E A mistake in counting the offspring; such a ratio is impossible

▶ **Explanation:** A 9:7 ratio suggests complementary gene action: pigment is produced only when at least one dominant allele is present at both loci ($A_B\_$). Any genotype with aa or bb is white.

21 **In a certain mouse strain, the allele Y gives yellow coat colour when heterozygous (Yy), but the homozygous genotype YY is lethal before birth. The recessive genotype yy produces non-yellow (agouti) mice. When two yellow mice are crossed, the observed live offspring are 2 yellow : 1 agouti. Which explanation is most consistent with these data?**

A Y is a completely dominant allele with normal viability.

B Y is recessive and only yy mice are yellow.

C **Y is a dominant allele that is lethal in the homozygous state, so YY embryos die and are not counted among the offspring.** ✓

D Y is an X-linked allele expressed only in males.

E Agouti genotype yy is lethal and removed from the population.

▶ **Explanation:** The cross Yy × Yy yields 1 YY : 2 Yy : 1 yy. If YY is lethal, only the 2 Yy (yellow) and 1 yy (agouti) survive, giving the observed 2:1 ratio.

22 **A particular autosomal dominant disorder shows incomplete penetrance: only 80% of individuals with genotype Dd actually show the disease phenotype. Genotype DD is lethal and dd is normal. A heterozygous affected person (Dd) and an unaffected person with genotype dd have a child. What is the probability that the child will SHOW the disease phenotype?**

A 1/2 (50%)

B **2/5 (40%)** ✓

C 1/4 (25%)

D 4/5 (80%)

E 0

▶ **Explanation:** The cross Dd $\times$ dd gives 1/2 Dd and 1/2 dd. Only Dd can show disease, and only 80% of Dd are affected: P(affected) $= (1/2) \times 0.8 = 0.4 = 2/5$.