Key

AP Biology Genetics Problems

Monohybrid Crosses (One-trait)

1. ***Sample Problem***: The Gene for tall is dominant over dwarf in the garden pea plant used by Mendel. A pea plant that comes from a line of plants that are all tall is crossed with a dwarf pea plant. What is the phenotype of the F1 generation? What is (are) its genotype(s)?

2. If the offspring generation of problem 1 is crossed with the tall plant from a tall lineage, what will be the phenotype(s) and in what ratios for the offspring? What will be the genotype(s) and in what ratios?

   b) 50% TT, 50% Tt

3. If the F1 generation of problem 1 is crossed with the dwarf parent from a dwarf lineage, what will be the genotypes and the ratios of the offspring, and the phenotypes and ratios of the offspring?

   b) ½ tall, ½ short

4. The genes for dark eyes (black and brown) usually dominate over genes for blue or gray eyes. A man with black eyes marries a woman with light gray eyes. They have two children, a boy with black eyes, and a girl with blue eyes. What are the genotypes of the man, his wife, the little boy, and the little girl?

   Boy: Bb, Girl: bb

5. A man with brown eyes marries a woman with blue eyes. They have 12 brown-eyed children. What are the genotypes of the man, his wife and all the children?

6. A brown-eyed man marries a blue-eyed woman. They have four children, two with brown eyes, and two with blue eyes. What are the genotypes of all these people?

   Bb and bb

7. A brown-eyed man with a blue-eyed mother marries a brown-eyed woman with a blue-eyed father. What is the probability that their first child will be brown-eyed? That the second child will be brown-eyed?

   75%

8. A man and a woman have 24 children. Of the children, 17 have brown eyes and 7 of the children have blue eyes. What are the genotypes of the parents?

9. Assume that the dimple is inherited as a simple dominant gene. A dimpled man whose mother has no dimple marries a woman with no dimple. What is the probability that they will have a child with a dimple?

10. Sickle cell anemia (SCA) is a human genetic disorder caused by a recessive allele. A couple plans to marry and wants to know the probability that they will have an affected child. With your knowledge of Mendelian inheritance, what can you tell them if (a) both are normal, but each has one affected parent and the other parent has no family history of SCA; and (b) the man is affected by the disorder, but the woman has no family history of SCA?

Multiple Alleles

11. Assume that blood type is inherited as A and B dominant over O, but A and B ~~incompletely~~ codominant dominate over each other. Genotypes AA and AO are then phenotypically type A, genotypes BB and BO are type B, genotype AB is type AB, and genotype OO is type O blood. A man with type A blood marries a woman with type A blood. They have the first child as blood type O. What are the genotypes of the father, mother, and baby?

$I^A i$, $I^A i$, BABY: ii

12. A man with type AB blood marries a woman with type O blood, but whose father was type A blood. What genotype would you expect their first child to have?

$I^A i$ or $I^B i$

13. A man with type B blood marries a woman with type A blood. They have six type AB children. What are the genotypes of the father, mother, and children?

$I^B I^B$, $I^A I^A$, CHILDREN: $I^A I^B$

14. A man whose father is type B and whose mother is type A, has a blood type A. He marries a type A woman, whose parents had the same blood types as his parents. What are the genotypes of the man and woman and what is the probability that their first child will be blood type A?

FATHER: $I^B i \times I^A i$ — 25% $I^A i$

15. A type A man whose mother was type O marries a woman with type B blood. Their son has type B blood. This son marries a girl with type B blood. They have 12 children. 10 are type B and 2 are type O. What are the genotypes of the man, woman, son, girl, and children?

MAN: $I^A i \times I^B$(woman), son: $I^B i \times I^B i$ (Girl), CHILDREN $I^B I^B$, $I^B i$, and ii

16. A man with type A blood marries a woman with type B blood. They have a type O child. What is the probability of their fifteenth child having type O blood?

1/4 (25%) $I^A i \times I^B i$ → 25% ii every child

17. A man whose father was AB and whose mother was B, has type A blood. He marries a woman with type A blood but whose father was type A and whose mother was type B. What is the probability that the first child will be type A? What is the probability that the second child will be type A? What is the probability that the third child will be type A?

$I^A i \times I^A i$, 3/4 or 75%, 75% for each

18. A man with type A blood marries a woman with type A blood. They have eight type A children, one type O child. What are the genotypes of the father, mother, the eight type A children, and the one type O child? $I^A i \times I^A i$, 8: $I^A I^A$ or $I^A i$, 1: ii

19. A man with group A blood marries a woman with group B blood. Their child has group O blood. What are the genotypes of these individuals? What other genotypes, and in what frequencies, would you expect in offspring from this marriage?

$I^A i \times I^B i$, child: ii, 25% $I^A I^B$, 25% $I^A i$, 25% $I^B i$

20. A man with type A blood marries three times. His first wife is type B. They have three children, types AB, A and A. This man marries again, this time to a woman with type A blood. They have two children, both type A. This man marries a type O woman, and they have four children, all type A. What are the genotypes of all these people?

MAN: $I^A I^A$ (most likely), WIFE 1: $I^B i$, 2: I^A ? 3: ii

21. Color pattern in a species of duck is determined by a single pair of genes with three alleles. Alleles *H* and *I* are codominant, and allele *i* is recessive to both. How many phenotypes are possible in a flock of ducks that contains all the possible combinations of these three alleles?

4 possible phenotypes:

HH + H*i* = H pheno. HI = HI pheno.

II + I*i* = I pheno. *ii* = I pheno

Dihybrid Crosses (Two-traits)

22. A man with a dimple and brown eyes (whose father had blue eyes but no dimples) marries a woman with a dimple and brown eyes (whose father had blue eyes with no dimple). What is the probability their first child will be blue-eyed and without a dimple? (Assume that dimple is a dominant over smooth cheeks, and brown eyes are dominant over blue).
    DdBb × DdBb → ddbb ? (1/4)(1/4) = 1/16
23. A blue-eyed woman with no dimple marries a man with brown eyes and a dimple (whose mother had blue eyes and no dimple). What is the probability that their first child will have blue eyes and a dimple? dd bb × BbDd → bbDd ? (1/2)(1/2) = 1/4
24. A man with blue eyes and a dimple (whose mother had blue eyes and no dimple) marries a woman with blue eyes and no dimple. What is the probability that their first child will be blue-eyed with no dimple?
    bbDd × bbdd → bbdd (1)(1/2) = 1/2
25. Assume that a cross was made between fruit flies of genotype AAbb and those of genotype aaBB. Give the Punnett square for the expected F_2 progeny types. What proportion of A-B-, A-bb, aaB-, and aabb progeny do you expect in the F_2? see attached
26. In some flowers, a true-breeding, red-flowered strain gives all pink flowers when crossed with a white-flowered strain: *RR* (red) × *rr* (white) → *Rr* (pink). If flower position is inherited as it is in peas, what will be the ratios of genotypes and phenotypes of the generation resulting from the following cross: Axial-red (true breeding) × terminal-white? What will be the ratios in the F_2 generation? F_1 = all axial, pink (geno = AaRr) F_2 = AaRr × AaRr (9:3:3:1)? → No, due to pink (see attached)
27. In sesame plants, the one-pod condition *(P)* is dominant to the three-pod condition *(p)*, and normal leaf *(L)* is dominant to wrinkled leaf *(l)*. These traits are inherited independently. Determine the genotypes for the two parents for all the possible matings producing the following offspring:
    a. 318 one-pod normal, 98 one-pod wrinkled PP Ll × P_ Ll
    b. 323 three-pod normal, 106 three-pod wrinkled pp Ll × pp Ll
    c. 401 one-pod normal PPLL × PPLL
    d. 150 one-pod normal, 147 one-pod wrinkled, 51 three-pod normal, 48 three-pod wrinkled —
    e. 223 one-pod normal, 72 one-pod wrinkled, 76 three-pod normal, 27 three-pod wrinkled
    PpLl × PpLl
28. Two traits are simultaneously examined in a cross of two pure-breeding pea-plant varieties. Pod shape can be either swollen or pinched. Seed color can be either green or yellow. A plant with the traits swollen, green is crossed with a plant with the traits pinched, yellow, and a resulting F1 plant is self-crossed. A total of 640 F2 progeny are phenotypically categorized as follows:

    Swollen, yellow 360
    Swollen, green 120
    Pinched, yellow 120
    Pinched, green 40

    9:3:3:1

    a. What is the phenotypic ratio observed for pod shape? Seed color? 3:1, 3:1
    b. What is the phenotypic ratio observed for both traits considered together? 9:3:3:1
    c. What is the dominance relationship for pod shape? Seed color?
    Swollen + Yellow dominant

29. Consider the following cross in pea plants, where smooth seed shape is dominant to wrinkled and yellow seed color is dominant to green. A plant with smooth, yellow seeds is crossed to a plant with wrinkled, green seeds. The peas produced by the offspring are all smooth and yellow. What are the genotypes of the parents? What are the genotypes of the offspring?

SSYY × ssyy → all SsYy offspring

Basic Probabilities

30. A student has a penny, nicked, a dime, and a quarter. She flips them all simultaneously and checks for heads or tails. What is the probability that all four coins will come up heads? She again flips all four coins. What is the probability that she will get four heads both times? What probability rule did you use to determine your answers?

a) $(1/2)(1/2)(1/2)(1/2) = 1/16$ b) $(1/16)(1/16)$ c. multiplication

31. The first child of two normally pigmented parents has albinism, a recessive trait that results from lack of the pigment melanin. Given that the normal allele is A and the albino allele is a, draw this pedigree and label both phenotypes and genotypes. What is the probability that the second child will be a carrier of the albino gene? Given that the second child is unaffected, what is the probability that he or she is a carrier? Aa × Aa

(see attached)

32. What is the probability that, if three identical coins were flipped, all would end up heads? What is the probability that the three coins would *not* either be all heads or tails?

$(1/2)(1/2)(1/2) = 1/8$, $1 - 1/8 = 7/8$

33. *Phenylketonuria* (PKU) is an inherited disease determined by a recessive allele. If a woman and her husband are both carriers, what is the probability of each of the following? Pp × Pp
    a. All three of their children will be normal. $(3/4)(3/4)(3/4) = 27/64$
    b. One *or* more of the three children will have the disease. $1 - 27/64 = 37/64$
    c. All three children will be afflicted with the disease.

    $(1/4)(1/4)(1/4) = 1/64$

34. What is the probability that each of the following pairs of parents will produce the indicated offspring (assume independent assortment of all gene pairs)?
    a. *AABBCC* × *aabbcc* → *AaBbCc* $(1)(1)(1) = 1$ (100%)
    b. *AABbCc* × *AaBbCc* → *AAbbCC* $(1/2)(1/4)(1/4) = 1/32$
    c. *AaBbCc* × *AaBbCc* → *AaBbCc* $(1/2)(1/2)(1/2) = 1/8$
    d. *aaBbCC* × *AABbcc* → *AaBbCc* $(1)(1/2)(1) = 1/2$

Trihybrid Crosses (Three-traits)

35. Using the forked-line approach and given the cross between two cats with the genotypes llSsdd and LlSsDd, what is the probability of a cat having the genotype llssdd? What is the probability of a cat having the short hair, white spotted, and non-diluted phenotype? *[short hair is dominant to long hair, white spotted coat is dominant to not spotted, diluted color is dominant to non-diluted coloring]*

llSsdd × LlSsDd → llssdd $(1/2)(1/4)(1/2) = 1/16$

36. Using the forked-line approach in a trihybrid cross involving three traits, where the pigments are both AaBbCc, what is the probability of their producing an offspring recessive for all three traits? What is the probability of producing an offspring with the phenotype A-bbC-?

AaBbCc × AaBbCc → aabbcc = $(1/4)(1/4)(1/4) = 1/64$

→ A_bbC_ = $(3/4)(1/4)(3/4) = 9/64$

Forked-Line Approach – see attached

37. The genotype of F_1 individuals in a tetrahybrid cross is AaBbCcDd. Assuming independent assortment of these four genes, what are the probabilities that F_2 offspring would have the following genotypes?

a. aabbccdd $(1/4)(1/4)(1/4)(1/4) = 1/256$
b. AaBbCcDd $(1/2)(1/2)(1/2)(1/2) = 1/16$
c. AABBCCDD $(1/4)(1/4)(1/4)(1/4) = 1/256$
d. AaBbccDd $(1/2)(1/2)(1/4)(1/2) = 1/32$
e. AaBBCCdd $(1/2)(1/4)(1/4)(1/4) = 1/128$

38. Flower position, stem length, and seed shape were three characters that Mendel chose to study. Each is controlled by an independently assorting gene and has dominant and recessive expression as follows:

Trait	*Dominant*	*Recessive*
Flower position	Axial *(A)*	Terminal *(a)*
Stem length	Tall *(L)*	Dwarf *(l)*
Seed shape	Round*(R)*	Wrinkled*(r)*

so – AaLlRr x AaLlRr

If a plant that is heterozygous for all three traits were allowed to self-fertilize, what proportion of the offspring would be expected to be as follows? (*Note:* Use the rules of probability instead of a huge Punnet square.)

a. homozygous for the three dominant traits AALLRR $= (1/4)(1/4)(1/4) = 1/64$
b. homozygous for the three recessive traits aallrr $= (1/4)(1/4)(1/4) = 1/64$
c. heterozygous for the three traits AaLlRr $= (1/2)(1/2)(1/2) = 1/8$
d. homozygous for axial and tall, heterozygous for round
AALLRr $= (1/4)(1/4)(1/2) = 1/32$

45. In pea plants, long stems are dominant to short stems, purple flowers are dominant to white, and round seeds are dominant to wrinkled. Each trait is determined by a single, different gene. A plant that is heterozygous at all three loci is self-crossed, and 2048 progeny are examined. How many of these plants would you expect to be long stemmed with purple flowers, producing wrinkled seeds?

LlPpRr x LlPpRr
of 2048 total

→ L_P_rr $= (3/4)(3/4)(1/4) = 9/64$ of 2048 = 288

25.

Bb			

F all AaBb !

F $F_1 \times F_1$ or AaBb × AaBb

exp 9 : 3 : 3 : 1

_B_ ([illegible])

A_bb (3/16)

aaB_ (3/16)

aabb (1/16)

26. A[illegible] × AaRr

	[illegible]	[illegible]	aR	ar
AR	[illegible]	A[illegible] r *	Aa RR	Aa Rr *
Ar	[illegible]	A[illegible]	Aa Rr *	Aa rr
aR	[illegible]	[illegible]a [illegible]r *	aa RR	aa Rr *
ar	[illegible]	[illegible]a rr	aa Rr *	aa rr

A_R_ = 3

A_Rr = 6

aaR_ = 1

aaRr = 2

A_rr = 3

aarr = 1