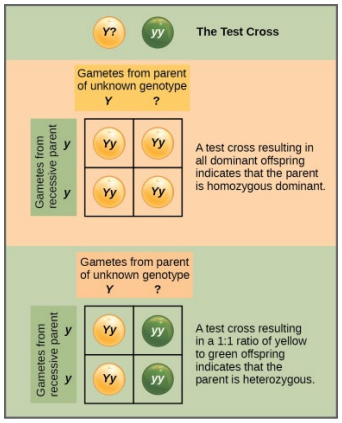
Biology 2e
Unit 3: Genetics
Chapter 12: Mendel's Experiments and Heredity

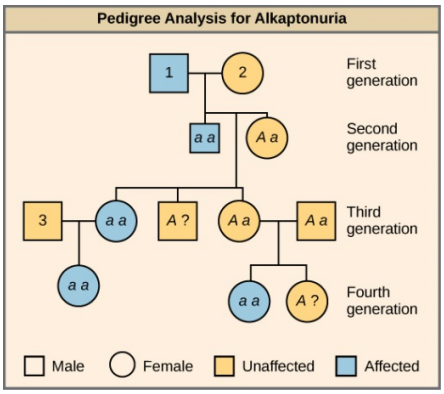
Visual Connection Questions

1. In pea plants, round peas (*R*) are dominant to wrinkled peas (*r*). You do a test cross between a pea plant with wrinkled peas (genotype *rr*) and a plant of unknown genotype that has round peas. You end up with three plants, all which have round peas. From this data, can you tell if the round pea parent plant is homozygous dominant or heterozygous? If the round pea parent plant is heterozygous, what is the probability that a random sample of 3 progeny peas will all be round?



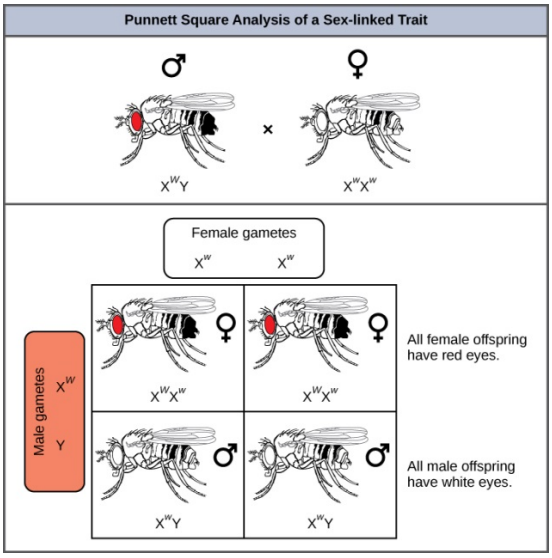
You cannot be sure if the plant is homozygous or heterozygous as the data set is too small: by random chance, all three plants might have acquired only the dominant gene even if the recessive one is present. If the round pea parent is heterozygous, there is a one-eighth probability that a random sample of three progeny peas will all be round.

2. What are the genotypes of the individuals labeled 1, 2 and 3?



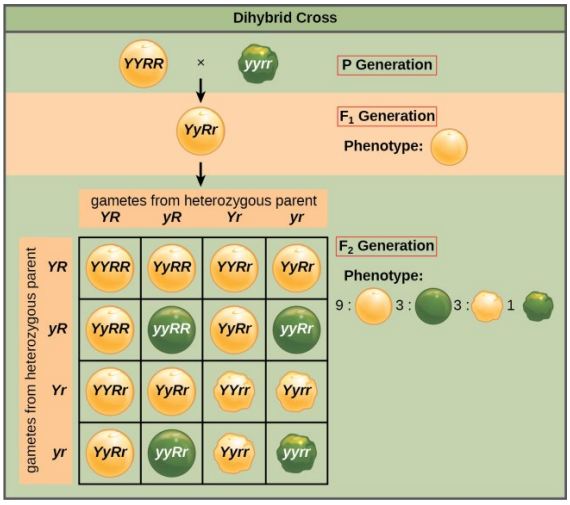
Individual 1 has the genotype *aa*. Individual 2 has the genotype *Aa*. Individual 3 has the genotype *Aa*.

3. What ratio of offspring would result from a cross between a white-eyed male and a female that is heterozygous for red eye color?



Half of the female offspring would be heterozygous (X^WX^w) with red eyes, and half would be homozygous recessive (X^wX^w) with white eyes. Half of the male offspring would be hemizygous dominant (X^WY) withe red yes, and half would be hemizygous recessive (X^wY) with white eyes.

4. Figure 12.16 In pea plants, purple flowers (P) are dominant to white flowers (p) and yellow peas (Y) are dominant to green peas (y). What are the possible genotypes and phenotypes for a cross between PpYY and ppYy pea plants? How many squares do you need to do a Punnett square analysis of this cross?



The possible genotypes are *PpYY*, *PpYy*, *ppYY*, and *ppYy*. The former two genotypes would result in plants with purple flowers and yellow peas, while the latter two genotypes would result in

plants with white flowers with yellow peas, for a 1:1 ratio of each phenotype. You only need a 2 × 2 Punnett square (four squares total) to do this analysis because two of the alleles are homozygous.

Review Questions

5. Mendel performed hybridizations by transferring pollen from the _____ of the male plant to the female ova.

a. anther

6. Which is one of the seven characteristics that Mendel observed in pea plants?

b. seed texture

7. Imagine you are performing a cross involving seed color in garden pea plants. What F_1 offspring would you expect if you cross true-breeding parents with green seeds and yellow seeds? Yellow seed color is dominant over green.

b. 100 percent yellow seeds

8. Consider a cross to investigate the pea pod texture trait, involving constricted or inflated pods. Mendel found that the traits behave according to a dominant/recessive pattern in which inflated pods were dominant. If you performed this cross and obtained 650 inflated-pod plants in the F_2 generation, approximately how many constricted-pod plants would you expect to have?

c. 217

9. A scientist pollinates a true-breeding pea plant with violet, terminal flowers with pollen from a true-breeding pea plant with white, axial flowers. Which of the following observations would most accurately describe the F_2 generation?

c. 75% violet flowers; 75% axial flowers

10. The observable traits expressed by an organism are described as its _____.

c. phenotype

11. A recessive trait will be observed in individuals that are _____ for that trait.

c. homozygous

12. If black and white true-breeding mice are mated and the result is all gray offspring, what inheritance pattern would this be indicative of?

d. incomplete dominance

13. The ABO blood groups in humans are expressed as the I^A, I^B, and *i* alleles. The I^A allele encodes the A blood group antigen, I^B encodes B, and *i* encodes O. Both A and B are dominant to O. If a heterozygous blood type A parent (I^Ai) and a heterozygous blood type B parent (I^Bi) mate, one quarter of their offspring will have AB blood type (I^AI^B) in which both antigens are expressed equally. Therefore, ABO blood groups are an example of:
d. multiple alleles and codominance

14. In a mating between two individuals that are heterozygous for a recessive lethal allele that is expressed *in utero*, what genotypic ratio (homozygous dominant:heterozygous:homozygous recessive) would you expect to observe in the offspring?
c. 1:2:0

15. If the allele encoding polydactyly (six fingers) is dominant why do most people have five fingers?
d. The polydactyl allele is very rare in the human population.

16. A farmer raises black and white chickens. To his surprise, when the first generation of eggs hatch all the chickens are black with white speckles throughout their feathers. What should the farmer expect when the eggs laid after interbreeding the speckled chickens hatch?
c. 50% of the offspring will be speckled, 25% will be black, and 25% will be white.

17. Assuming no gene linkage, in a dihybrid cross of *AABB* × *aabb* with *AaBb* F_1 heterozygotes, what is the ratio of the F_1 gametes (*AB*, *aB*, *Ab*, *ab*) that will give rise to the F_2 offspring?
a. 1:1:1:1

18. The forked line and probability methods make use of what probability rule?
b. product rule

19. How many different offspring genotypes are expected in a trihybrid cross between parents heterozygous for all three traits when the traits behave in a dominant and recessive pattern? How many phenotypes?
d. 27 genotypes; 8 phenotypes

20. Labrador retrievers' fur color is controlled by two alleles, E and B. Any dog with the ee__ genotype develops into a yellow lab, while B_E_ dogs become black labs and bbE_ dogs become chocolate labs. This is an example of _____.
a. Epistasis

21. Which of the following situations does **not** follow the Law of Independent Assortment?
d. Men are more likely to experience hemophilia than women.

Critical Thinking Questions

22. Describe one of the reasons why the garden pea was an excellent choice of model system for studying inheritance.

The garden pea is sessile and has flowers that close tightly during self-pollination. These features help to prevent accidental or unintentional fertilizations that could have diminished the accuracy of Mendel's data.

23. How would you perform a reciprocal cross for the characteristic of stem height in the garden pea?

Two sets of P0 parents would be used. In the first cross, pollen would be transferred from a true-breeding tall plant to the stigma of a true-breeding dwarf plant. In the second cross, pollen would be transferred from a true-breeding dwarf plant to the stigma of a true-breeding tall plant. For each cross, F_1 and F_2 offspring would be analyzed to determine if offspring traits were affected according to which parent donated each trait.

24. Mendel performs a cross using a true-breeding pea plant with round, yellow seeds and a true-breeding pea plant with green, wrinkled seeds. What is the probability that offspring will have green, round seeds? Calculate the probability for the F_1 and F_2 generations.

Since we are calculating the probability of two independent events occurring simultaneously, we use the product rule.
F_1 generation: Since green seed color is recessive, there is a 0% probability that any plants in the F_1 generation will have green, round seeds.
F_2 generation: The probability of growing an F_2 generation plant with green seeds is ¼, while the probability of growing an F_2 generation plant with round seeds is ¾. We can use the product rule to then calculate the probability of a plant with green, round seeds:
1/4 × 3/4 = 3/16

25. Calculate the probability of selecting a heart or a face card when heart suit face cards are excluded from a standard deck of cards. Is this outcome more or less likely than selecting a heart suit face card from a standard deck of cards?

A standard deck of cards contains 52 cards, 13 of which are hearts and 12 of which are face cards. 3 are heart suit face cards which are excluded from the deck, leaving total of 49 cards, 10 of which are hearts and 9 are face cards.
Heart suit **or** face card: This calculation requires the sum rule since there are multiple pathways to successfully pulling a desired card.

10/49 + 9/49 = 19/49 = 38.77%

The probability of selecting a heart suit or a face card is significantly more likely than the probability of selecting a heart suit face card (3/52 = 5.8%).

26. The gene for flower position in pea plants exists as axial or terminal alleles. Given that axial is dominant to terminal, list all of the possible F_1 and F_2 genotypes and phenotypes from a cross involving parents that are homozygous for each trait. Express genotypes with conventional genetic abbreviations.

Because axial is dominant, the gene would be designated as *A*. F_1 would be all heterozygous *Aa* with axial phenotype. F_2 would have possible genotypes of *AA*, *Aa*, and *aa*; these would correspond to axial, axial, and terminal phenotypes, respectively.

27. Use a Punnett square to predict the offspring in a cross between a dwarf pea plant (homozygous recessive) and a tall pea plant (heterozygous). What is the phenotypic ratio of the offspring?

The Punnett square would be 2 × 2 and will have *T* and *T* along the top, and *T* and *t* along the left side. Clockwise from the top left, the genotypes listed within the boxes will be *Tt*, *Tt*, *tt*, and *tt*. The phenotypic ratio will be 1 tall:1 dwarf.

28. Can a human male be a carrier of red-green color blindness?

No, males can only express color blindness. They cannot carry it because an individual needs two X chromosomes to be a carrier.

29. Why is it more efficient to perform a test cross with a homozygous recessive donor than a homozygous dominant donor? How could the same information still be found with a homozygous dominant donor?

Using a homozygous recessive donor is more efficient because the genotype of the unknown parent can be determined in a single generation. If a homozygous dominant donor was used, the unknown genotype could still be determined. Instead of knowing the unknown genotype through the F_1 phenotype, the F_1 offspring would have to be self-crossed (as Mendel allowed his pea plants to self-pollinate) and the F_2 generation phenotypes would be used to determine the unknown F_0 genotype.

30. Use the probability method to calculate the genotypes and genotypic proportions of a cross between *AABBCc* and *Aabbcc* parents.

Considering each gene separately, the cross at *A* will produce offspring of which half are *AA* and half are *Aa*; *B* will produce all *Bb*; *C* will produce half *Cc* and half *cc*. Proportions then are (1/2) × (1) × (1/2), or 1/4 *AABbCc*; continuing for the other possibilities yields 1/4 *AABbcc*, 1/4 *AaBbCc*, and 1/4 *AaBbcc*. The proportions therefore are 1:1:1:1.

31. Explain epistasis in terms of its Greek language roots “standing upon.”

Epistasis describes an antagonistic interaction between genes wherein one gene masks or interferes with the expression of another. The gene that is interfering is referred to as epistatic, as if it is “standing upon” the other (hypostatic) gene to block its expression.

32. In Section 12.3, "Laws of Inheritance," an example of epistasis was given for the summer squash. Cross white *WwYy* heterozygotes to prove the phenotypic ratio of 12 white:3 yellow:1 green that was given in the text.

The cross can be represented as a 4 × 4 Punnett square, with the following gametes for each parent: *WY*, *Wy*, *wY*, and *wy*. For all 12 of the offspring that express a dominant W gene, the offspring will be white. The three offspring that are homozygous recessive for *w* but express a dominant *Y* gene will be yellow. The remaining *wwyy* offspring will be green.

33. People with trisomy 21 develop Down's syndrome. What law of Mendelian inheritance is violated in this disease? What is the most likely way this occurs?

In any trisomy disorder, a patient inherits 3 copies of a chromosome instead of the normal pair. This violates the Law of Segregation, and usually occurs when the chromosomes fail to separate during the first round of meiosis.

34. A heterozygous pea plant produces violet flowers and yellow, round seeds. Describe the expected genotypes of the gametes produced by Mendelian inheritance. If all three genes are found on the same arm of one chromosome should a scientist predict that inheritance patterns will follow Mendelian genetics?

Mendelian inheritance would predict that all three genes are inherited independently. There are therefore 8 different gamete genotype possibilities: VYR, VYr, VyR, Vyr, vYR, vYr, vyR, vyr. If all three genes are found on the same chromosome arm, independent assortment is unlikely to occur because the genes are close together (linked).