

## CHAPTER 9—FUNDAMENTALS OF GENETICS

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### MULTIPLE CHOICE

1. Mendel prevented self-pollination of his plants by
- growing only one kind of plant.
  - preventing crossing-over.
  - removing the anthers of the plants.
  - removing the stigmas of the plants.

ANS: C                      DIF: 1                      OBJ: 9-1.1

2. The “father” of genetics was
- T. A. Knight.
  - Hans Krebs.
  - Gregor Mendel.
  - None of the above

ANS: C                      DIF: 1                      OBJ: 9-1.1

3. Mendel obtained his P generation by allowing the plants to
- self-pollinate.
  - cross-pollinate.
  - assort independently.
  - segregate.

ANS: A                      DIF: 1                      OBJ: 9-1.2

4. What is the probability that the offspring of a homozygous dominant individual and a homozygous recessive individual will exhibit the dominant phenotype?
- 0.25
  - 0.5
  - 0.66
  - 1.0

ANS: D                      DIF: 1                      OBJ: 9-2.2

5. True-breeding pea plants always
- are pollinated by hand.
  - produce offspring each of which can have multiple forms of a trait.
  - produce offspring each of which can have only one form of a trait.
  - are heterozygous.

ANS: C                      DIF: 1                      OBJ: 9-1.2

6. The first filial ( $F_1$ ) generation is the result of
- cross-pollination among parents and the next generation.
  - crosses between individuals of the parental generation.
  - crosses between the offspring of a parental cross.
  - self-fertilization between parental stock.

ANS: B                      DIF: 1                      OBJ: 9-1.2

7. Which of the following is the designation for Mendel’s original pure strains of plants?
- P
  - $P_1$
  - $F_1$
  - $F_2$

ANS: A                      DIF: 1                      OBJ: 9-1.2



15. When Mendel crossed pea plants that differed in two characteristics, such as flower color and plant height,
- these experiments led to his law of segregation.
  - he found that the inheritance of one trait did not influence the inheritance of the other trait.
  - he found that the inheritance of one trait influenced the inheritance of the other trait.
  - these experiments were considered failures because the importance of his work was not recognized.

ANS: B                      DIF: 1                      OBJ: 9-1.4

16. The phenotype of an organism
- represents its genetic composition.
  - reflects all the traits that are actually expressed.
  - occurs only in dominant pure organisms.
  - cannot be seen.

ANS: B                      DIF: 1                      OBJ: 9-2.1

17. If an individual has two recessive alleles for the same trait, the individual is said to be
- homozygous for the trait.
  - haploid for the trait.
  - heterozygous for the trait.
  - mutated.

ANS: A                      DIF: 1                      OBJ: 9-2.1

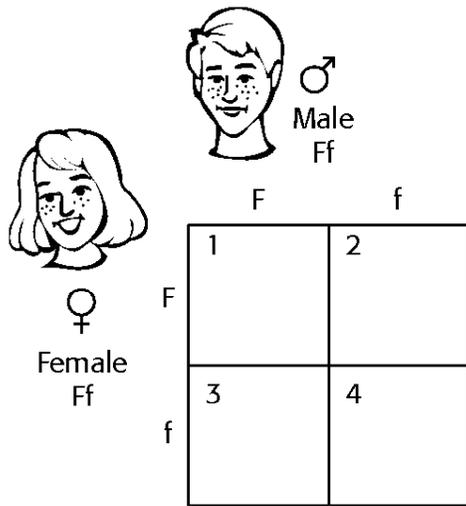
18. An individual heterozygous for a trait and an individual homozygous recessive for the trait are crossed and produce many offspring. These offspring are likely to be
- all the same genotype.
  - of two different phenotypes.
  - of three different phenotypes.
  - all the same phenotype.

ANS: B                      DIF: 2                      OBJ: 9-2.1

19. Tallness (T) is dominant over shortness (t) in pea plants. Which of the following represents the genotype of a pea plant that is heterozygous for tallness?
- |       |       |
|-------|-------|
| a. T  | c. Tt |
| b. TT | d. tt |

ANS: C                      DIF: 2                      OBJ: 9-2.1

In humans, having freckles (F) is dominant over not having freckles (f). The inheritance of these traits can be studied using a Punnett square similar to the one shown below.



20. Refer to the illustration above. The genotype represented in box 1 in the Punnett square would
- be homozygous for freckles.
  - have an extra freckles chromosome.
  - be heterozygous for freckles.
  - have freckles chromosomes.

ANS: A                      DIF: 2                      OBJ: 9-2.3

21. Refer to the illustration above. The genotype in box 3 of the Punnett square is
- FF.
  - Ff.
  - ff.
  - None of the above

ANS: B                      DIF: 2                      OBJ: 9-2.3

22. A trait that occurs in 450 individuals out of a total of 1,800 individuals occurs with a probability of
- 0.04.
  - 0.25.
  - 0.50.
  - 0.75.

ANS: B                      DIF: 2                      OBJ: 9-2.2

23. How many different phenotypes can be produced by a pair of codominant alleles?
- 1
  - 2
  - 3
  - 4

ANS: C                      DIF: 2                      OBJ: 9-2.1

	Gl	Gi	gl	gi
Gl				<b>5</b>
Gi	<b>2</b>	<b>3</b>	<b>7</b>	
gl	<b>1</b>		<b>4</b>	<b>6</b>
gi				

**Pea plants**

G = green pod  
 g = yellow pod  
 I = inflated pod  
 i = constricted pod

24. Refer to the illustration above. The phenotype represented by box 1 is
- green, inflated.
  - green, constricted.
  - yellow, inflated.
  - yellow, constricted.

ANS: A                      DIF: 2                      OBJ: 9-2.3

25. Refer to the illustration above. The genotype represented by box 2 is
- Ggli.
  - GGIi.
  - GI.
  - Gi.

ANS: B                      DIF: 2                      OBJ: 9-2.3

26. 2,000 yellow seeds : 8,000 total seeds ::
- 1 : 6
  - 1 : 8
  - 1 : 3
  - 1 : 4

ANS: D                      DIF: 2                      OBJ: 9-2.2

In rabbits, black fur (B) is dominant over brown fur (b). Consider the following cross between two rabbits.

**Bb x Bb**

	B	b
B	1	2
b	3	4

27. Refer to the illustration above. The device shown, which is used to determine the probable outcome of genetic crosses, is called a
- Mendelian box.
  - Punnett square.
  - genetic graph.
  - phenotypic paradox.

ANS: B                      DIF: 1                      OBJ: 9-2.3

28. Refer to the illustration above. Both of the parents in the cross are
- black.
  - brown.
  - homozygous dominant.
  - homozygous recessive.

ANS: A                      DIF: 2                      OBJ: 9-2.1

29. Refer to the illustration above. The phenotype of the offspring indicated by box 3 would be
- brown.
  - black.
  - a mixture of brown and black.
  - The phenotype cannot be determined.

ANS: B                      DIF: 2                      OBJ: 9-2.1

30. Refer to the illustration above. The genotypic ratio of the F<sub>1</sub> generation would be
- 1:1.
  - 3:1.
  - 1:3.
  - 1:2:1.

ANS: D                      DIF: 2                      OBJ: 9-2.1

31. What is the expected genotypic ratio resulting from a homozygous dominant × heterozygous monohybrid cross?
- 1:0
  - 1:1
  - 1:2:1
  - 1:3:1

ANS: B                      DIF: 2                      OBJ: 9-2.1

32. What fraction of the offspring resulting from a heterozygous × heterozygous dihybrid cross are homozygous recessive for both traits?
- 9/16
  - 1/4
  - 3/16
  - 1/16

ANS: D                      DIF: 2                      OBJ: 9-2.5

33. What is the expected genotypic ratio resulting from a heterozygous × heterozygous monohybrid cross?
- 1:2:1
  - 1:3:1
  - 1:2
  - 1:0

ANS: A                      DIF: 2                      OBJ: 9-2.5

34. What is the expected phenotypic ratio resulting from a homozygous dominant × heterozygous monohybrid cross?
- 1:3:1
  - 1:2:1
  - 2:1
  - 1:0

ANS: D                      DIF: 2                      OBJ: 9-2.2

	R $Y$	R $y$	r $Y$	r $y$
R $Y$	<b>7</b>		<b>6</b>	
R $y$			<b>1</b>	<b>3</b>
r $Y$		<b>2</b>	<b>5</b>	<b>4</b>
r $y$				

### Pea plants

R = round seed  
r = wrinkled seed  
Y = yellow seed  
y = green seed

35. Refer to the illustration above. The phenotype represented by box 1 is
- round, yellow.
  - round, green.
  - wrinkled, yellow.
  - wrinkled, green.

ANS: A                      DIF: 2                      OBJ: 9-2.3

36. Refer to the illustration above. The genotype represented by box 2 is
- R $RY$ .
  - R $rYY$ .
  - R $rYy$ .
  - r $rYy$ .

ANS: C                      DIF: 2                      OBJ: 9-2.3

37. Refer to the illustration above. Which of the following boxes represents the same phenotype as box 7?
- 3
  - 4
  - 5
  - 6

ANS: D                      DIF: 2                      OBJ: 9-2.3

38. An organism that has inherited two of the same alleles of a gene from its parents is called
- hereditary.
  - heterozygous.
  - homozygous.
  - a mutation.

ANS: C                      DIF: 1                      OBJ: 9-1.5

39. In pea plants, yellow seeds are dominant over green seeds. What would be the expected genotype ratio in a cross between a plant with green seeds and a plant that is heterozygous for seed color?
- 1:3
  - 1:2:1
  - 4:1
  - 1:1

ANS: D                      DIF: 2                      OBJ: 9-2.2

40. codominance : both traits are displayed ::
- probability : crosses
  - heterozygous : alleles are the same
  - homozygous : alleles are the same
  - Punnett square : chromosomes combine

ANS: C                      DIF: 2                      OBJ: 9-2.1

41. The difference between a monohybrid cross and a dihybrid cross is that
- monohybrid crosses involve traits for which only one allele exists, while dihybrid traits involve two alleles.
  - monohybrid crosses involve self-pollination, while dihybrid crosses involve cross-pollination.
  - monohybrid crosses involve one trait; dihybrid crosses involve two traits.
  - dihybrid crosses require two Punnett squares; monohybrid crosses need only one.

ANS: C                      DIF: 1                      OBJ: 9-2.5

42. What fraction of the offspring resulting from a heterozygous  $\times$  heterozygous dihybrid cross are heterozygous for both traits?
- 9/16
  - 1/4
  - 3/16
  - 1/16

ANS: B                      DIF: 2                      OBJ: 9-2.5

43. A cross of two individuals for a single contrasting trait is called
- monohybrid.
  - dihybrid.
  - dominant.
  - codominant.

ANS: A                      DIF: 1                      OBJ: 9-2.5

## COMPLETION

1. A reproductive process in which fertilization occurs within a single plant is called \_\_\_\_\_.

ANS: self-pollination

DIF: 1                      OBJ: 9-1.1

2. The transferring of pollen between plants is called \_\_\_\_\_.

ANS: cross-pollination

DIF: 1                      OBJ: 9-1.1

3. Mendel produced true-breeding strains of pea plants through the process of \_\_\_\_\_.

ANS: self-pollination

DIF: 1                      OBJ: 9-1.1

4. When two members of the  $F_1$  generation are allowed to breed with each other, the offspring are referred to as the \_\_\_\_\_ generation.

ANS:  $F_2$

DIF: 1                      OBJ: 9-1.2

5. Mendel called the offspring of the P generation the first filial generation, or the \_\_\_\_\_ generation.

ANS: F<sub>1</sub>

DIF: 1                      OBJ: 9-1.2

6. A \_\_\_\_\_ is a method for determining the genotype of an individual with a dominant phenotype.

ANS: testcross

DIF: 1                      OBJ: 9-2.4

7. In heterozygous individuals, only the \_\_\_\_\_ allele achieves expression.

ANS: dominant

DIF: 1                      OBJ: 9-1.3

8. A trait that is not expressed in the F<sub>1</sub> generation resulting from the crossbreeding of two genetically different, true-breeding organisms is called \_\_\_\_\_.

ANS: recessive

DIF: 1                      OBJ: 9-1.3

9. The principle that states that one factor may mask the effect of another factor is the principle of \_\_\_\_\_.

ANS: dominance

DIF: 1                      OBJ: 9-1.3

10. In Mendel's experiments, a trait that disappeared in the F<sub>1</sub> generation but reappeared in the F<sub>2</sub> generation was always a \_\_\_\_\_.

ANS: recessive trait

DIF: 2                      OBJ: 9-1.3

11. The statement that the members of each pair of alleles separate when gametes are formed is known as the \_\_\_\_\_.

ANS: law of segregation

DIF: 1                      OBJ: 9-1.4

12. Different forms of a particular gene, which Mendel called *factors*, are now called \_\_\_\_\_.

ANS: alleles

DIF: 1                    OBJ: 9-1.5

13. The cellular process that results in the segregation of Mendel's factors is \_\_\_\_\_.

ANS: meiosis

DIF: 1                    OBJ: 9-1.5

14. The portion of a DNA molecule containing the coded instructions that result in a particular characteristic of an organism is called a(n) \_\_\_\_\_.

ANS: gene

DIF: 1                    OBJ: 9-1.5

15. An organism that has two identical alleles for a trait is called \_\_\_\_\_.

ANS: homozygous

DIF: 1                    OBJ: 9-2.1

16. An organism's \_\_\_\_\_ refers to the set of alleles it has inherited.

ANS: genotype

DIF: 1                    OBJ: 9-2.1

17. The appearance of an organism as a result of its genotype is its \_\_\_\_\_.

ANS: phenotype

DIF: 1                    OBJ: 9-2.1

18. The likelihood that a specific event will occur is called \_\_\_\_\_.

ANS: probability

DIF: 1                    OBJ: 9-2.2

19.

		<b>RRYy x RrYy</b>				
		RY	Ry	RY	Ry	
RY						
Ry	<b>X</b>					
rY						
ry						

**Pea plants**

R = round seed  
 r = wrinkled seed  
 Y = yellow seed  
 y = green seed

Refer to the illustration above. The box labeled “X” represents the phenotype

\_\_\_\_\_.

ANS: round, yellow seeds

DIF: 1                      OBJ: 9-2.3

20. A fractional probability of 1/2 is the same as a decimal probability of \_\_\_\_\_.

ANS: 0.5

DIF: 2                      OBJ: 9-2.2

In pea plants, tallness (T) is dominant over shortness (t). Crosses between plants with these traits can be analyzed using a Punnett square similar to the one shown below.

	T	t
T	1	2
t	3	4

21. Refer to the illustration above. The parents shown in the Punnett square are likely to have offspring with a genotype ratio of \_\_\_\_\_.

ANS: 1:2:1

DIF: 2                      OBJ: 9-2.3

22. Refer to the illustration above. Box 2 and box \_\_\_\_\_ in the Punnett square represent plants that would be heterozygous for tallness.

ANS: 3

DIF: 2                      OBJ: 9-2.3

23. Refer to the illustration above. The phenotype of the plant that would be represented in box 4 of the Punnett square would be \_\_\_\_\_.

ANS: short

DIF: 2                      OBJ: 9-2.1

24. Refer to the illustration above. The genotype of both parents shown in the Punnett square above is \_\_\_\_\_.

ANS: Tt

DIF: 2                      OBJ: 9-2.1

25. A situation in which both alleles for a trait are expressed in a heterozygous offspring is called \_\_\_\_\_.

ANS: codominance

DIF: 1                      OBJ: 9-2.1

26. A pattern of heredity in which a heterozygous individual has a phenotype that is intermediate between the phenotypes of its two homozygous parents is called \_\_\_\_\_.

ANS: incomplete dominance

DIF: 1                      OBJ: 9-2.1

27. A table used to determine and diagram the results of a genetic cross is called a \_\_\_\_\_.

ANS: Punnett square

DIF: 1                      OBJ: 9-2.3

28. In genetics, lowercase letters are usually used to indicate \_\_\_\_\_.

ANS: recessive traits

DIF: 1                      OBJ: 9-1.3

29. A cross involving two pairs of contrasting traits is a(n) \_\_\_\_\_ cross.

ANS: dihybrid

DIF: 1                      OBJ: 9-2.5

## PROBLEM

1. In tomato plants, tallness is dominant over dwarfness and hairy stems are dominant over hairless stems. True-breeding (homozygous) plants that are tall and have hairy stems are available. True-breeding (homozygous) plants that are dwarf and have hairless stems are also available. Design an experiment to determine whether the genes for height and hairiness of stem are on the same or different chromosomes. Explain how you will be able to determine from the results whether the genes are on the same chromosome or different chromosomes, and whether they are close to each other or far apart if they are on the same chromosome. Write your answer in the space below.

ANS:

The experiment should be designed to produce  $F_1$  plants that are then allowed to pollinate the other plants' flowers and produce an  $F_2$  generation of plants. If the  $F_2$  generation has four different phenotypes present in approximate proportions of 9/16 tall and hairy, 3/16 tall and hairless, 3/16 dwarf and hairy, and 1/16 dwarf and hairless, then the student can conclude that the genes for height and hairiness are on different chromosomes. If the  $F_2$  generation has only two different phenotypes present in approximate proportions of 3/4 tall and hairy and 1/4 dwarf and hairless, then the student can conclude that the genes for height and hairiness are on the same chromosome. The student could also conclude that the genes are located very close to each other on the chromosome. If the  $F_2$  generation has four different phenotypes with the tall and hairless types composing less than 3/16 of the total number and the dwarf and hairy types composing less than 3/16 of the total number, then the student could conclude that the genes for height and hairiness are on the same chromosome but not located adjacent to each other.

DIF: 3

OBJ: 9-1.5

2. A scientist crossed true-breeding tall and hairy-stemmed tomato plants with true-breeding dwarf and hairless-stemmed tomato plants. He found that all of the F<sub>1</sub> plants produced as a result of this cross were tall and hairy-stemmed. He then allowed the F<sub>1</sub> plants to pollinate each other and obtained 1000 F<sub>2</sub> plants. Of these 1000 F<sub>2</sub> plants, he observed the following numbers of four different phenotypes:

557 tall and hairy-stemmed plants	192 dwarf and hairy-stemmed plants
180 tall and hairless-stemmed plants	71 dwarf and hairless-stemmed plants

Write your answers to the following in the space below or on a separate sheet of paper.

- Which height characteristic is dominant, tallness or dwarfness?
- Which stem characteristic is dominant, hairiness or hairlessness?
- What are the genotypes of the original, true-breeding parents? (Be sure to indicate what the symbols you use stand for.)
- What are the genotypes of the F<sub>1</sub> hybrid plants? (Be sure to indicate what the symbols you use stand for.)
- What are the genotypes of the four types of plants found in the F<sub>2</sub> generation? (Be sure to indicate what the symbols you use stand for.)
- What were the expected numbers of plants of each type in the F<sub>2</sub> generation? (Round off to the nearest whole numbers.)
- Why did the observed numbers of plants of each type in the F<sub>2</sub> generation differ from the expected?
- How could this experiment have been changed to obtain numbers of plants of each type in the F<sub>2</sub> generation that were closer to the expected numbers?

ANS:

- Tallness is dominant.
- Hairiness is dominant.
- Let T stand for tallness, t stand for dwarfness, H stand for hairiness, and h stand for hairlessness. The tall, hairy-stemmed true-breeding parent has the genotype TTHH. The dwarf, hairless-stemmed true-breeding parent has the genotype tthh.
- Use the same symbols as in answer c above. The F<sub>1</sub> plants all have the same genotype, which is TtHh.
- Use the same symbols as in answer c above. The possible genotypes of the F<sub>2</sub> plants are the following:
  - tall and hairy-stemmed plants: TTHH, TTHh, TtHh, TtHH
  - tall and hairless-stemmed plants: TThh, Tthh
  - dwarf and hairy-stemmed plants: tHH, tHh
  - dwarf and hairless-stemmed plants: tthh
- The expected numbers were as follows: 563 tall and hairy-stemmed plants, 188 tall and hairless-stemmed plants, 188 dwarf and hairy-stemmed plants, 63 dwarf and hairless-stemmed plants. (Notice that rounding causes the total to exceed 1000.)
- The expected numbers are based on probabilities. The actual numbers should be close to the expected, but would not likely be exactly the expected numbers.
- Increasing the sample size, say to 10,000 plants, would likely result in the observed numbers being closer to the expected numbers. Again, this is because of probabilities.

DIF: 3

OBJ: 9-2.2

## ESSAY

1. How might you go about determining the genotype of a red-flowering plant where red is dominant over white? Write your answer in the space below.

ANS:

You could do a testcross by crossing the red-flowering plant of unknown genotype with a white-flowering plant. If the F<sub>1</sub> generation includes any plants that have white flowers, then the red-flowering parent is heterozygous. If all the F<sub>1</sub> plants have red flowers, the parent is homozygous dominant.

DIF: 2                      OBJ: 9-2.4

2. Describe pollination in pea plants. Write your answer in the space below.

ANS:

The reproductive structures of seed plants are located inside the flowers. In pea plants, each flower has both male and female structures. The male reproductive parts, the anthers, produce pollen grains that contain sperm. The female reproductive structure produces the egg. The tip of the female structure is called the stigma. Pollination is the transfer of pollen from anthers to stigma.

DIF: 1                      OBJ: 9-1.1

3. In what ways did Mendel's methods help ensure his success in unraveling the mechanics of heredity? Write your answer in the space below.

ANS:

Mendel's choice of plants to study was fortunate since pea plants displayed several traits in contrasting forms. His use of large numbers of samples allowed the gathering of statistically significant amounts of data. In addition, he kept very careful records and used logical, orderly methods that minimized the possibility of errors.

DIF: 2                      OBJ: 9-1.2

4. What conclusions did Gregor Mendel reach based on his observations of pea plants? Write your answer in the space below.

ANS:

Mendel studied the hereditary patterns of pea plants by observing the results of controlled crosses. After studying the results of these crosses, Mendel concluded that patterns of inheritance were governed by three principles: (1) the law of dominance and recessiveness, (2) the law of segregation, and (3) the law of independent assortment.

DIF: 1                      OBJ: 9-1.4

5. Describe Mendel's observation regarding independent assortment. Write your answer in the space below.

ANS:

From his work on pea plants, Mendel concluded that factors for different characteristics are not connected. This principle became the law of independent assortment: Factors for different characteristics are distributed independently of one another during the formation of gametes.

DIF: 1                      OBJ: 9-1.4

6. What are three ways to express the probability of an event that occurs 500 times out of 2,000 total trials? Write your answer in the space below.

ANS:

The probability may be expressed as a ratio (1:4), as a decimal (0.25), or as a percentage (25 percent).

DIF: 2                      OBJ: 9-2.2

7. Describe how genotype and phenotype are related, and give an example. Write your answer in the space below.

ANS:

The genetic makeup of an organism is its genotype. The external appearance of an organism as a result of its genotype is its phenotype. For example, the genotype of a pure tall plant is TT. It consists of two dominant alleles for height—T and T. The plant's phenotype, or appearance, is tall.

DIF: 2                      OBJ: 9-2.1

8. Explain what is meant by homozygous and heterozygous, and give an example of each. Write your answer in the space below.

ANS:

When both alleles of a pair are the same, an organism is said to be homozygous for that characteristic. An organism may be homozygous dominant or homozygous recessive. A pea plant that is homozygous dominant for height will have the genotype TT. A pea plant that is homozygous recessive for height will have the genotype tt. When the two alleles in the pair are not the same—for example, when the genotype is Tt—the organism is heterozygous for that characteristic.

DIF: 1                      OBJ: 9-2.1

9. All of the offspring resulting from a cross between a red snapdragon and a white snapdragon are pink. What is a possible explanation for this? Write your answer in the space below.

ANS:

Incomplete dominance is a heredity pattern that occurs when neither of two alleles of a gene is dominant. In other words, the heterozygous offspring in this cross display a trait that is intermediate to the traits exhibited by the two homozygous parents. In this case, the genotype RR produces red flowers, the genotype rr produces white flowers, and the genotype Rr produces pink flowers.

DIF: 2                      OBJ: 9-2.1