

Genetics: An Integrated Approach (Sanders)
Chapter 2 Transmission Genetics

2.1 Multiple-Choice Questions

1) Mendel performed many types of crosses, including those in which the same genotypes are crossed but the sexes of the parents are switched. These are known as

- A) replicate crosses.
- B) reciprocal crosses.
- C) test crosses.
- D) monohybrid crosses.
- E) dihybrid crosses.

Answer: B

Section: 2.1

Skill: Knowledge/Comprehension

2) Crosses in which F₁ plants heterozygous for a given allele are crossed to generate a 3:1 phenotypic ratio in the F₂ generation are known as

- A) replicate crosses.
- B) reciprocal crosses.
- C) test crosses.
- D) monohybrid crosses.
- E) dihybrid crosses.

Answer: D

Section: 2.2

Skill: Knowledge/Comprehension

3) In peas, the round allele is dominant over the wrinkled allele. If a plant with round peas is crossed to a plant with wrinkled peas, all of the resulting plants have round peas. What is the genotype of the parents in this cross?

- A) $RR \times rr$
- B) $RR \times Rr$
- C) $Rr \times rr$
- D) $Rr \times Rr$
- E) $rr \times rr$

Answer: A

Section: 2.2

Skill: Application/Analysis

4) In peas, the yellow allele is dominant over the green allele. If a plant with yellow peas is crossed to a plant with green peas, the resulting plants are 50% yellow and 50% green. What is the genotype of the parents in this cross?

- A) $YY \times yy$
- B) $YY \times Yy$
- C) $Yy \times yy$
- D) $Yy \times Yy$
- E) $yy \times yy$

Answer: C

Section: 2.2

Skill: Application/Analysis

5) Assuming independent assortment, what phenotypic ratio would you expect to see if an individual with the genotype $RrGg$ is self-crossed?

- A) 1:3
- B) 9:3:3:1
- C) 1:2:1
- D) 1:3:2:1
- E) 3:1

Answer: B

Section: 2.3

Skill: Application/Analysis

6) What genotypic ratio would you expect to see among the progeny of a monohybrid cross?

- A) 1:3
- B) 9:3:3:1
- C) 1:2:1
- D) 1:3:2:1
- E) 3:1

Answer: C

Section: 2.2

Skill: Application/Analysis

7) A couple has four children. What is the probability that they would have four boys?

- A) $1/2$
- B) $1/4$
- C) $1/8$
- D) $1/16$
- E) $1/32$

Answer: D

Section: 2.4

Skill: Application/Analysis

8) Humans have a gene, "T," that is involved in muscle formation of the tongue. Individuals with the one allele can roll their tongues, while individuals with the other allele cannot. If both parents can roll their tongues, but their child cannot, what can be said about the mode of inheritance?

- A) Tongue rolling is dominant.
- B) Tongue rolling is recessive.
- C) The parents were both homozygous, but the child was heterozygous.
- D) Tongue rolling is dominant, and both parents were heterozygous (Tt).
- E) Tongue rolling is recessive, and both parents were heterozygous (Tt).

Answer: D

Section: 2.2

Skill: Synthesis/Evaluation

9) In peas, axial (*A*) flower position is dominant to terminal (*a*), tall (*L*) is dominant to short (*l*), and yellow (*Y*) is dominant to green (*y*). If a plant that is heterozygous for all three traits is allowed to self-fertilize, how many of the offspring would be dominant for all three traits?

- A) 3/64
- B) 9/64
- C) 27/64
- D) 32/64
- E) 64/64

Answer: C

Section: 2.3

Skill: Application/Analysis

10) In peas, axial (*A*) flower position is dominant to terminal (*a*), and tall (*L*) is dominant to short (*l*). If a plant that is heterozygous for both traits is allowed to self-fertilize, how many of the offspring would also be heterozygous for both traits?

- A) 9/16
- B) 4/16
- C) 3/16
- D) 2/16
- E) 1/16

Answer: B

Section: 2.3

Skill: Application/Analysis

11) The law of segregation states that the F₂ progeny of F₁ heterozygous plants will exhibit

- A) a 3:1 phenotypic ratio.
- B) a 9:3:3:1 phenotypic ratio.
- C) a 1:2:1 genotypic ratio.
- D) a 9:3:3:1 phenotypic ratio and 1:2:1 genotypic ratio.
- E) both a 3:1 phenotypic ratio and a 1:2:1 genotypic ratio.

Answer: E

Section: 2.3

Skill: Knowledge/Comprehension

- 12) The law of independent assortment would predict that the F₂ progeny of F₁ heterozygous plants will exhibit a
- A) 3:1 phenotypic ratio.
 - B) 9:3:3:1 phenotypic ratio.
 - C) 1:2:1 genotypic ratio.
 - D) 9:3:3:1 phenotypic ratio and 1:2:1 genotypic ratio.
 - E) 3:1 phenotypic ratio and 1:2:1 genotypic ratio.

Answer: B

Section: 2.3

Skill: Knowledge/Comprehension

- 13) What phenotypic ratio would you expect as a result of a test cross between a dihybrid organism and one that is homozygous recessive for alleles at two independent loci?

- A) 3:1
- B) 1:2:1
- C) 1:1:1:1
- D) 9:3:3:1
- E) 9:4:2:1

Answer: C

Section: 2.3

Skill: Knowledge/Comprehension

- 14) How many possible gametes can be produced by a short plant with yellow, round peas with a heterozygous genotype (*YyRrSs*)?

- A) 3
- B) 6
- C) 8
- D) 10
- E) 12

Answer: C

Section: 2.3

Skill: Application/Analysis

- 15) By convention, when the difference between the *observed* experimental outcomes and the *expected* outcome is less than 5 percent (< 0.05), the experimental results are considered to be

- A) within normal expected range.
- B) statistically significantly and different from the expected outcome.
- C) not significant.
- D) less than one standard deviation from the mean.
- E) equal to the mean.

Answer: B

Section: 2.4

Skill: Knowledge/Comprehension

16) The statistical interpretation of a chi-square value is determined by identifying the

- A) mean.
- B) degrees of freedom.
- C) average.
- D) P value.
- E) joint probability.

Answer: D

Section: 2.5

Skill: Knowledge/Comprehension

17) The P value is a quantitative expression of the probability that the results of another experiment of the same size and structure will *deviate as much or more from expected results by chance*. The greater the difference between observed and expected results of an experiment,

- A) the lower the χ^2 value and the lower the P value.
- B) the greater the χ^2 value and the greater the P value.
- C) the greater the χ^2 value and the lower the P value.
- D) the lower the χ^2 value and the greater the P value.
- E) the greater the χ^2 value; but the P value is unaffected.

Answer: C

Section: 2.5

Skill: Knowledge/Comprehension

18) The statistical interpretation of a chi-square value is determined by identifying the P value for each experiment, and the P value is dependent on the number of degrees of freedom (df) in the experiment being examined. For the coin flip experiment, the df value is equal to 1. What would be the df value for the example about rolling a 1 in a single roll of a die?

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

Answer: E

Section: 2.5

Skill: Application/Analysis

19) The genes responsible for some of the traits that Mendel observed have been recently identified and have helped in determining how molecular variation produces morphologic variation in pea plants. Allelic variation in the *Sbe1* gene, which produces starch-branching enzyme 1, is responsible for which trait in peas?

- A) round and wrinkled pea shape
- B) yellow and green pea color
- C) purple and white flowers
- D) tall and short plant height
- E) axial and terminal flower position

Answer: A

Section: 2.6

Skill: Knowledge/Comprehension

20) In 1997, a gene called *Le* was discovered by two research groups led by David Martin and Diane Lester. Allelic variation in the *Le* gene, which controls elongation of the plant stem between branches, is responsible for which trait in peas?

- A) inflated and constricted pod shape
- B) yellow and green pod color
- C) purple and white flowers
- D) tall and short plant height
- E) axial and terminal flower position

Answer: D

Section: 2.6

Skill: Knowledge/Comprehension

2.2 Short-Answer Questions

1) Mendel performed numerous controlled genetic crosses to obtain strains that consistently produced a single phenotype without variation. What are these strains that consistently produce the same phenotype called?

Answer: pure-breeding or true-breeding strains

Section: 2.1

Skill: Knowledge/Comprehension

2) In a test cross, a pure-breeding plant is crossed with a plant suspected to be heterozygous (*Aa*). What is the genotype of the pure-breeding plant?

Answer: *aa*

Section: 2.1

Skill: Application/Analysis

3) Why did Mendel cut off the nascent anthers during the process of artificial cross-fertilization?

Answer: to prevent self-fertilization or to prevent uncontrolled crosses

Section: 2.2

Skill: Knowledge/Comprehension

4) What simple type of cross that looks at the inheritance of only one trait could be used to illustrate Mendel's law of segregation?

Answer: monohybrid cross

Section: 2.2

Skill: Knowledge/Comprehension

5) If an affected individual is born to parents who are unaffected, what is the likely mode of inheritance?

Answer: autosomal recessive

Section: 2.2

Skill: Knowledge/Comprehension

6) What type of cross would be used to illustrate Mendel's law of independent assortment?

Answer: dihybrid cross (or test cross)

Section: 2.2

Skill: Knowledge/Comprehension

7) A cross between a short pea plant and a tall pea plant results in a 1:1 genotypic *and* phenotypic ratio in the offspring. What are the genotypes of the parent plants?

Answer: $Ss \times ss$ (heterozygous \times homozygous recessive)

Section: 2.2

Skill: Application/Analysis

8) What is the probability of rolling one six-sided die and obtaining a 1 or a 2?

Answer: $1/6 + 1/6 = 2/6 = 1/3$

Section: 2.4

Skill: Application/Analysis

9) What is the probability of rolling one six-sided die and obtaining any number but 6?

Answer: $1 - 1/6 = 5/6$

Section: 2.4

Skill: Application/Analysis

10) What is the probability of rolling two six-sided dice and obtaining two 4s?

Answer: $1/6 \times 1/6 = 1/36$

Section: 2.4

Skill: Application/Analysis

11) What is the probability of rolling two six-sided dice and obtaining at least one 3?

Answer: $(1/6) + (5/6)(1/6) = 6/36 + 5/36 = 11/36$

Section: 2.4

Skill: Application/Analysis

12) What is the probability of rolling two six-sided dice and obtaining an odd number on at least one die?

Answer: $9/36 + 9/36 + 9/36 = 27/36 = 3/4$

Prob. of rolling odd number the 1st roll only = $3/6$ (odd) \times $3/6$ (even) = $9/36$

Prob. of rolling odd number the 2nd roll only = $3/6$ (even) \times $3/6$ (odd) = $9/36$

Prob. of rolling odd number both rolls = $3/6$ (odd) \times $3/6$ (odd) = $9/36$

Prob. of any one of these three possible scenarios = addition rule

Section: 2.4

Skill: Application/Analysis

For the following questions, determine which of the four rules of probability theory best fit the situation.

13) When calculating the probability of a given genotype in a trihybrid cross, you can generate a Punnett square. Which of the rules of probability can be used to calculate the joint probability of simultaneous inheritance of multiple alleles?

Answer: the product rule

Section: 2.4

Skill: Synthesis/Evaluation

14) In a cross between individuals who are both heterozygous (carriers) for a recessive disease such as albinism, you would like to determine the risk of one or more children to inherit the recessive phenotype. Which of the rules of probability can be used to calculate the probability of a particular combination of events that each have two alternative outcomes?

Answer: binomial probability

Section: 2.4

Skill: Synthesis/Evaluation

15) You have self-fertilized a plant with round seed that is heterozygous, and you want to determine what proportion of the offspring will be not only dominant, but true-breeding. Which of the rules of probability can be used to calculate the probability of obtaining a particular outcome when specific information about that outcome modifies the probability calculation?

Answer: conditional probability

Section: 2.4

Skill: Synthesis/Evaluation

16) In a dihybrid cross, you want to calculate the probability that an F₂ progeny of the cross will inherit both dominant phenotypes. Which of the rules of probability can be used to calculate the probability of obtaining that combination of alleles?

Answer: the product rule

Section: 2.4

Skill: Synthesis/Evaluation

17) The statistical value obtained from the chi-square analysis refers to the probability that the deviations of between the observed numbers and the expected numbers are caused by what?

Answer: random chance

Section: 2.5

Skill: Knowledge/Comprehension

18) A normal distribution curve contains all the possible experimental outcomes in graph form. The tall central segment of the curve represents the outcomes with the highest probability of occurrence. The average outcome, represented by the center of the data distribution, is known as what?

Answer: the mean (μ)

Section: 2.5

Skill: Knowledge/Comprehension

19) The probability of experimental outcomes gets smaller toward the farthest left and right portions of the curve. The probability of a given observation compared to all possible outcomes is known as what?

Answer: the standard deviation (σ)

Section: 2.5

Skill: Knowledge/Comprehension

20) Geneticists must be able to compare the outcomes they obtain in their experiments to the outcomes that might be expected to occur. Which test would they use to confirm that the difference between observed and expected can be attributed to chance?

Answer: chi-square test

Section: 2.5

Skill: Knowledge/Comprehension

2.3 Fill-in-the-Blank Questions

1) One key to Mendel's success was choosing to observe _____ traits, which exhibit one of two possible phenotypes.

Answer: dichotomous

Section: 2.1

Skill: Knowledge/Comprehension

2) The hereditary particles that are passed from one generation are called *alleles* in modern terminology. This term had not been invented in Mendel's time; instead, he determined that two "_____" (alleles) were present for each trait in a plant and together determined the phenotype of the trait.

Answer: elementen

Section: 2.2

Skill: Knowledge/Comprehension

3) A ratio of 9:3:3:1 is expected among the F₂ progeny of a dihybrid cross as a result of _____ of alleles at two loci.

Answer: independent assortment

Section: 2.3

Skill: Knowledge/Comprehension

4) Binomial expansion is a complex genetic calculation requiring repetition and precision in the use of the product rule and the sum rule. A shortcut called _____ eliminates the need for these repetitive calculations and can be used for any number of expansions between 0 and the *n*th power to yield the size of each possible class and the total number of classes possible.

Answer: Pascal's triangle

Section: 2.4

Skill: Knowledge/Comprehension

5) The *P* value is dependent on the number of _____, which is equal to the number of independent variables in an experiment.

Answer: degrees of freedom (df)

Section: 2.5

Skill: Knowledge/Comprehension

2.4 Essay Questions

1) How did the study of physics with Professors Doppler and Ettinghausen influence Mendel's understanding of genetics?

Answer: Doppler, an experimental physicist famous for the Doppler effect, espoused a "particulate" view of physics and taught Mendel how to separate individual characteristics from one another in experiments. Professor Ettinghausen taught Mendel the mathematics of combinatorial analysis. Mendel would apply each of these lessons to his later research. Mendel's superior insight came principally from his familiarity with quantitative thinking and his understanding of the particulate nature of matter learned through the study of physics with Doppler. Central to Mendel's experimental success was counting the number of progeny with specific phenotypes. This logical and now routine component of data gathering was the key to Mendel's ability to formulate the hypotheses that explained his results. Under Doppler and Ettinghausen, Mendel had learned to study individual properties of matter separately and to think in quantitative terms about combinations of outcomes.

Section: 2.1

Skill: Synthesis/Evaluation

2) Describe the traits that make *Pisum sativum* an ideal organism for genetic studies. Why did Mendel ultimately decide not to include exterior seed coat color (gray vs. white) as one of the traits he analyzed?

Answer: There are many varieties of peas with distinct heritable features in the form of dichotomous phenotypes that can be easily observed and quantified. In addition, mating of plants can be closely controlled. Since each pea plant has both sperm-producing (stamens) and egg-producing (carpels) organs, they can be self-crossed to generate true-breeding plants. After creating these true-breeding plants, Mendel could test for dominant or recessive inheritance patterns by cross-pollination (fertilization between different plants). Mendel initially selected an eighth trait producing either gray or white exterior seed coats. Early in his analysis, he saw that plants with purple flowers *always* had gray seed coats and that those with white flowers *always* had white seed coats. He speculated that flower color and seed-coat color were determined by the same genetic mechanism, and he was correct. (The pigment anthocyanin is produced by plants that have purple flower color and gray seed coats, but a mutation eliminates anthocyanin production in plants with white flowers and white seed coats.)

Section: 2.1

Skill: Synthesis/Evaluation

3) Describe the blending theory of heredity and how Mendel's results help to reject this theory.

Answer: The blending theory viewed the traits of progeny as a mixture of the characteristics possessed by the two parental forms. Under this theory, progeny were believed to display characteristics that were approximately intermediate between those of the parents. Mendel reasoned that if the blending theory were true, he would see evidence of it in each trait. If no blending were seen in individual traits, the blending theory would be disproved. F₁ experimental results reject the blending theory of heredity because all F₁ progeny have the same phenotype (i.e., the dominant phenotype) that is indistinguishable from the phenotype of one of the pure-breeding parents. This specifically contradicts the blending theory prediction that the F₁ would display a mixture of the parental phenotypes. The persistence of the dominant phenotype and the reemergence of the recessive phenotype in the F₂ also contradict the blending theory.

Section: 2.2

Skill: Synthesis/Evaluation

4) What are Mendel's first and second laws, and what do they state?

Answer:

First Law: Law of Segregation The two alleles for each trait will separate from one another during gamete formation, and each allele will have an equal probability (1/2) of inclusion in a gamete. Random union of gametes at fertilization will unite one gamete from each parent to produce progeny in ratios that are determined by chance.

Second Law: Law of Independent Assortment During gamete formation, the segregation of alleles at one locus is independent of the segregation of alleles at another locus.

Section: 2.2

Skill: Synthesis/Evaluation

5) In Guinea pigs, short hair (*S*) is dominant over long hair (*s*), rough coat (*R*) is dominant over smooth coat (*r*), and black hair (*B*) is dominant over white hair (*b*). List the possible gametes that can be produced by each of the individuals below.

Answer:

SSRRbb: *SRb*

ssRrBB: *sRB, srB*

SsRrbb: *SRb, Srb, sRb, srb*

SsRrBb: *SRB, SRb, SrB, Srb, sRB, sRb, srB, srb*

Section: 2.3

Skill: Synthesis/Evaluation