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 F_1 plants heterozygous for a given allele are crossed to generate a 3:1 phenotypic ratio in the F_2 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. A plant with round peas was crossed to a plant with wrinkled peas and all of the resulting plants had 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) The blending theory would predict that the phenotype seen in the F_1 generation from a cross between a pure breeding plant with dark purple flowers and a pure breeding plant with white flowers would be _____.

A) dark purple
B) light purple
C) white

D) a 3:1 ratio of purple to white flowers
E) a 1:1 ratio of purple to white flowers

Answer: B
Section: 2.1
Skill: Application/Analysis

5) In peas, the yellow allele is dominant over the green allele. A plant with yellow peas was crossed to a plant with green peas. The resulting plants were 50% yellow and 50% green. What is the genotype of the parents in this cross?

A) *YY* × *yy*
B) *YY* × *Yy*
C) *Yy* × *yy*
D) *Yy* × *Yy*
E) *yy* × *yy*

Answer: C
Section: 2.2
Skill: Application/Analysis

6) 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

7) 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

8) A couple has four children. What is the probability that they 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

9) Humans have a gene, *T*, that is involved in muscle formation of the tongue. Individuals homozygous for one allele can roll their tongues, while individuals homozygous for 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: 2.6
Skill: Synthesis/Evaluation

10) 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 show the dominant phenotype 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

11) 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) 1/4
C) 3/16
D) 1/8
E) 1/16

Answer: B
Section: 2.3
Skill: Application/Analysis

12) The law of segregation would predict that the F_2 progeny of F_1 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: E
Section: 2.2
Skill: Knowledge/Comprehension

13) The law of independent assortment would predict that the F_2 progeny of F_1 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

14) 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: Application/Analysis

15) How many different types of 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

16) By convention, when an *observed* experimental outcome has a probability of occurrence of less than 5% (<0.05), the experimental results are considered to be _____.

A) within normal expected range
B) statistically significant 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: 2.5
Skill: Knowledge/Comprehension

17) 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

18) The *P* value is a quantitative expression of the probability that the results of another experiment of the same size and structure will *deviate from expected results as much as or more than 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

19) The statistical interpretation of a χ^2 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 a coin flip experiment, the df value is equal to 1. You perform an experiment to determine how many times out of 100 die rolls that you roll a "1" in a single roll. What would the df value be equal to?
A) 1
B) 2
C) 3
D) 4
E) 5

Answer: E
Section: 2.5
Skill: Application/Analysis

20) 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

21) 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

22) The gene L determines hair length in rabbits. The gene B determines hair color. A rabbit with long, black hair is crossed to a rabbit with short, white hair. All the offspring have long, black hair. What are the genotypes of the parents?

A) *LLBB* × *llbb*
B) *LlBb* × *LlBb*
C) *LlBb* × *llbb*
D) *Llbb* × *llBb*
E) Impossible to determine from the information given

Answer: A
Section: 2.3
Skill: Application/Analysis

23) In rabbits, long hair and black fur are produced by the dominant alleles *L* and *B*, which assort independently. The genotype *ll* produces short hair and the genotype *bb* produces white fur. A cross between a male with short, black fur and a female with long, white fur produces four offspring with short, black fur, four offspring with long, white fur, four offspring with short, white fur, and four offspring with long, black fur. What are the genotypes of the parents?

A) *llBB* × *LLbb*
B) *LlBb* × *LlBb*
C) *llBb* × *Llbb*
D) *LLBB* × *llbb*
E) Impossible to determine from the information given.

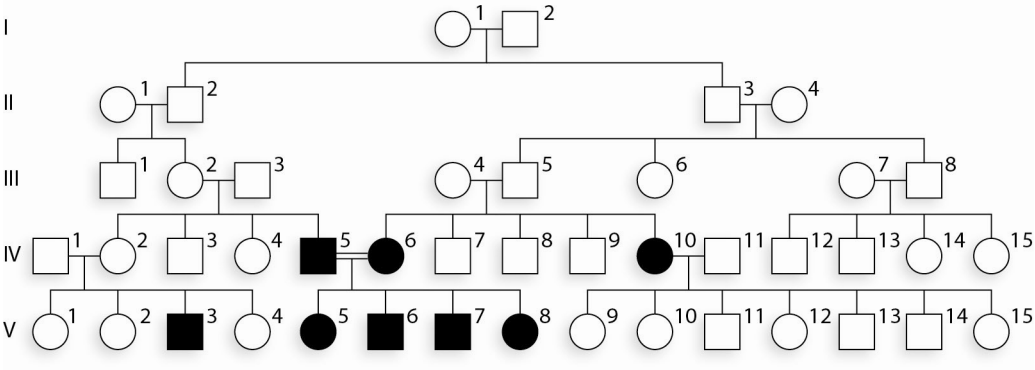
Answer: C
Section: 2.3
Skill: Application/Analysis

24) You count 1000 F_2 seeds from a monohybrid cross. How many do you expect to display the dominant phenotype?

A) 1000
B) 750
C) 500
D) 250
E) 0

Answer: B
Section: 2.5
Skill: Application/Analysis

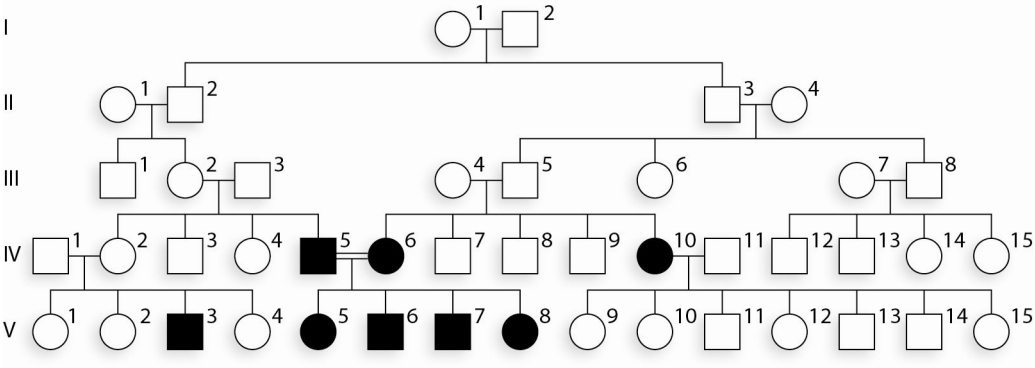
25) In the accompanying figure, the chance that individual III-2 is a heterozygous carrier is _____.



A) 0%
B) 25%
C) 50%
D) 75%
E) 100%

Answer: E
Section: 2.6
Skill: Application /Analysis

26) In the accompanying figure, the chance that individual IV-7 is a heterozygous carrier is _____.



A) 1/4
B) 1/3
C) 1/2
D) 2/3
E) 3/4

Answer: D
Section: 2.6
Skill: Application/Analysis

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 investigates 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: 2.6
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: 2.3
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* × *ss* (heterozygous × 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 4's?

Answer: 1/6 × 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: Probability of die 1 being a 3 and die 2 not: 1/6 × 5/6 = 5/36
Probability of die 2 being a 3 and die 1 not: 1/6 × 5/6 = 5/36
Probability of die 1 and 2 being a 3: 1/6 × 1/6 = 1/36
Probability of any of these possibilities = addition rule: 5/36 + 5/36 + 1/6 = 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
Probability of rolling odd number the first die only = 3/6 (odd) × 3/6 (even) = 9/36
Probability of rolling odd number the second die only = 3/6 (even) × 3/6 (odd) = 9/36
Probability of rolling odd number both dice = 3/6 (odd) × 3/6 (odd) = 9/36
Probability of any one of these three possible scenarios = addition rule
Section: 2.4
Skill: Application/Analysis

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 seeds that is heterozygous, and you want to determine what proportion of the offspring will be not only dominant, but also 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 F_2 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 a chi-square analysis refers to the probability that the deviations 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) 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 outcomes 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 F_2 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 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. F_1 experimental results reject the blending theory of heredity because all F_1 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 F_1 would display a mixture of the parental phenotypes. The persistence of the dominant phenotype and the reemergence of the recessive phenotype in the F_2 also contradict the blending theory.
Section: 2.1
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.

Sections: 2.2 and 2.3
Skill: Knowledge/Comprehension

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 all the different possible gametes that can be produced by each of the individuals below.

a. *SSRRbb*
b. *ssRrBB*
c. *SsRrbb*
d. *SsRrBb*

Answer:

a. *SSRRbb: SRb*
b. *ssRrBB: sRB, srB*
c. *SsRrbb: SRb, Srb, sRb, srb*
d. *SsRrBb: SRB, SRb, SrB, Srb, sRB, sRb, srB, srb*

Section: 2.3
Skill: Application/Analysis