

Review, Data Analysis and Deviations from Mendelism

Several practice problems follow. These are representative of the kinds of problems you will see on homework and exams. If you need help, check out the hints on the second page. However, try the problems without help at first. If you do need help, try reading just the first sentence or two of the hint to get started. For several of these problems, the branch-diagram approach described in Russell Chapter 2 will be helpful.

2. What types of ratios are likely to occur in crosses when dealing with a single gene pair?
 - a. 15:1, 1:2
 - b. 9:7, 12:3:1
 - c. 3:1, 1:1, 1:2:1
 - d. 9:3:3:1, 1:2:1
 - e. 1:1:1:1, 1:4:6:4:1

2. Apply the product law to a coin-flip situation. What is the probability that on three flips of a coin, heads will occur on all three flips?
 - a. 3/16
 - b. 1/4
 - c. 1/2
 - d. 1/8
 - e. insufficient information to answer this question

3. Assume that a Chi-square test was conducted to test the goodness of fit to a 3:1 ratio and a Chi-square value of 2.62 was obtained. Should the null hypothesis be accepted? How many degrees of freedom would be associated with this test of significance?

4. Assume that in a series of experiments, plants with round seeds were crossed to plants with wrinkled seeds and the following offspring were obtained: 220 round; 180 wrinkled.
 - i) What is the most probable genotype of each parent?
 - ii) What genotypic and phenotypic ratios are expected?
 - iii) Based on the information provided in part (b) above, what are the expected numbers of progeny of each phenotypic class?

5. Two organisms, AABBCDD and aabbccdd, are mated to produce an F₁ which is self-fertilized. If the capital letters represent dominant, independently assorting alleles, what proportion of the F₂ genotypes will be homozygous recessive for all four loci?

6. Dentinogenesis imperfecta is a rare, autosomal, dominantly inherited disease of the teeth which occurs about one in 8000 (Witkop, 1957). The teeth are somewhat brown in color and the crowns wear down rapidly. Assume that a male with dentinogenesis imperfecta and no family history of the disease (i.e., assume he is a heterozygote), marries a woman with normal teeth. What is the probability that:
 - i) their first child will have dentinogenesis imperfecta?
 - ii) their first two children will have dentinogenesis imperfecta?
 - iii) their first child will be a girl with dentinogenesis imperfecta?

7. What are the expected genotypic and phenotypic ratios in the F₂ of a monohybrid cross? A dihybrid

cross?

8. Visit the following web page and select “Visit the Pedigree Tests web site”. Answer the questions associated with each of the four pedigrees.

http://www.jbpub.com/humanbiology/4e/active_learning_links_chapter.cfm?chapter=16

9. In chickens the genotype $rr\ pp$ produces single combs; $R\ P-$, walnut comb; $rr\ P-$, pea comb; and, $R\ pp$, rose comb. If $rr\ PP$ (pea) are crossed to $RR\ pp$ (rose). What would be the progeny’s comb type?

- a. Rose
- b. Single
- c. Walnut
- d. Pea
- e. More than one of the above is true.

10. In chickens, most individuals have unfeathered shanks when they are homozygous for recessive genes at two loci; the presence of a single dominant gene at either locus causes feathers. What is the feathered-unfeathered ratio in their offspring if chickens heterozygous at both loci are crossed?

- a. 9:7
- b. 12:4
- c. 13:3
- d. 15:1

11. In mice, the allele A , causes agouti banding of hairs, and is dominant to the allele a , so that aa mice are solid black. The allele, C , causes color and is dominant to c , and cc mice are albinos. When a mouse is albino, its color cannot be shown. Heterozygous $Cc\ Aa$ mice are crossed to $cc\ aa$ mice. What will the phenotypic ratios be in the progeny?

- a. 2 agouti: 1 black: 1 albino
- b. 1 agouti: 2 black: 1 albino
- c. 1 agouti: 1 black: 2 albino
- d. 1 agouti: 1 albino
- e. None above are correct.

12. Many of the color varieties of summer squash are determined by several interacting loci: AA or Aa give white, $aaBB$ or $aaBb$ give yellow, and $aabb$ produces green. Assume that two fully heterozygous plants are crossed. Give the phenotypes (with frequencies) of the offspring

13. In humans, there is a dominant allele that causes vitiligo, where small-unpigmented spots appear on the body. Also, there is a recessive allele for another gene that causes albinism, which causes the entire body to be unpigmented. Vitiligo cannot be seen in albinos. A man with vitiligo had an albino mother and normal father. If the man has a child by a phenotypically normal skinned woman who had an albino father, what is the probability of having a phenotypically normal child?

- a. 0
- b. 1/8
- c. 2/8
- d. 3/8
- e. 4/8
- f. None above are correct.

14. A parakeet with green plumage is crossed to a white parakeet. The progeny are all green. Crossing these progeny together gave the following offspring: 3 white, 8 blue, 29 green, and 9 yellow. Propose a genetic hypothesis to explain the results. That is, give the genotypes and phenotypes of the parents, the F1 and the F2 individuals.

15. In the parakeet problem given above, propose a biochemical basis for the various colors.

16. Brachyphalangy is lethal when homozygous and is dominant in humans. Heterozygotes have

characteristically short fingers. Ability to roll the tongue is dominant to non-rolling. Two short-fingered persons, one not able to roll his tongue and the other heterozygous for the tongue-rolling allele, marry. What phenotypic ratios are expected in their living progeny?

17. In oats, there are two pairs of alleles that interact to determine seed hull color. A cross between two homozygous varieties of oats, one with white-hulled seeds and one with black-hulled seeds, produced an F1 with black hulled seeds. The cross F1 x F1 produced in the F2 the following proportions: 12/16 black: 3/16 gray: 1/16 white. Which genotypes correspond to which phenotypes in the F2? What were the genotypes of the parents?

18. Barred plumage in chickens is caused by a sex-linked dominant allele (B). Birds with two copies of the recessive b allele have non-barred plumage. If a rooster from a true-breeding barred strain is crossed to a hen from a true-breeding nonbarred strain, what kind of male and female chicks will be produced, and in what ratios?

19. Determining the sex of chicks is difficult without sacrificing them, but seeing whether or not they have the barred or non-barred feather color pattern is easy. Making use of the fact that barred is a sex-linked (Z-linked) dominant, choose a cross that would allow you to identify the sex of chicks.

- Heterozygous barred female x Hemizygous nonbarred male
- Hemizygous barred male x Homozygous nonbarred female
- Hemizygous barred female x Homozygous nonbarred male
- Heterozygous barred male x Hemizygous nonbarred female
- Homozygous barred male x Hemizygous nonbarred female.

20. What is the difference between a sex-linked and a sex-influenced trait?

21. List two human genetic disorders that are thought to be due to genetic anticipation.

Hints and Solutions:

2. The web page contains solutions for each problem.

3. In this type of problem, first decide what kind of gametes each parent can produce. Here, each parent can only produce one kind of gamete. The rrPP parent produces rP gametes, and the Rrpp parent produces Rp gametes. You now know the genotype of the zygote produced, and therefore you know the phenotype.

4)(i) Assuming that round (W) is dominant to wrinkled (w): Ww, ww

(ii) 1:1 wrinkled: round and 1:1 Ww:ww

(iii) 200

5. 1/256

6. i) $\frac{1}{2}$; ii) $\frac{1}{2} * \frac{1}{2} = \frac{1}{4}$; iii) $\frac{1}{2} * \frac{1}{2} = \frac{1}{4}$

4. Start this problem by writing out the cross AaBb x AaBb. You know the ratio of the offspring of this cross: 9 A-B- : 3 aaB- : 3 A-bb : 1 aabb. Now you only need to assign phenotypes to each genotype. Only one genotype produces unfeathered shanks: aabb, all the other genotypes have feathered shanks.

7. This inheritance pattern is very similar to the mouse agouti/black/albino system. A man with vitiligo must have at least one copy of the dominant allele that causes the condition, and he must have at least one copy of the dominant allele at the gene that causes albinism, so he must be A-C-. Since his mother was albino, he must have inherited a 'c' from here. Vitiligo is rare, so it's safe to assume that his mother was aa. So his genotype is AaCc. The woman in the problem had an albino father; assume that her mother was homozygous for the normal allele at each locus: aaCc. At this point, you can determine which kinds of gametes each parent can produce (one parent can produce four kinds of gametes, the other can produce two kinds) and construct a Punnett Square. Or, you can use the product rule or a branching diagram to determine the probability of a phenotypically normal child when the parents are: AaCc x aaCc (see Review Material).

10. Each parent is heterozygous for the brachyphalangy allele (Bb). So one parent is aaBb and the other is AaBb. Use the product rule, a branching diagram, or a Punnett square to calculate expected ratios in the offspring. Remember that the BB genotype is lethal.

12. Remember that in birds, females are the heterogametic sex. So the barred males can be represented as $Z^B Z^B$ homozygotes, and the non-barred females as $Z^b W$. Female offspring will inherit their Z chromosome from their father. Male offspring will inherit one Z chromosome from their father and one from their mother.

13. As above, females are the heterogametic (and therefore hemizygous) sex. All the daughters of a nonbarred male will be non-barred, while all the sons of a barred female will have the dominant barred allele.

Solutions to Recommended Problems 1:

1. c
2. d
3. No, 1 degree of freedom
4. i) Assuming that round (W) is dominant to wrinkled (w): Ww and ww; ii) phenotypic: 1 round: 1 wrinkled, genotypic 1Ww: 1ww; iii) 200
5. 1/256
6. i) $\frac{1}{2}$; ii) $\frac{1}{2} * \frac{1}{2} = \frac{1}{4}$; iii) $\frac{1}{2} * \frac{1}{2} = \frac{1}{4}$
7. Monohybrid genotypic ratio 1:2:1; phenotypic ratio 3:1. Dihybrid genotypic ratio 1:2:1:2:4:2:1:2:1; phenotypic ratio 9:3:3:1
8. Solutions on web page
9. Walnut
10. 15:1
11. 1 agouti: 1 black: 2 albino
12. 12:3:1, as follows

9/16 A-B-	3/16 A-bb	3/16 aaB-	1/16 aabb
white	white	yellow	green

 So: 12/16 white: 3/16 yellow: 1/16 green
13. 3/8
14. Genotypes P: AA BB x aa bb;
 Phenotypes Green white
 F1: Aa Bb x Aa Bb;

	green	green		
F2:	9 $A- B-$	3 $A- bb$	3 $aa B-$	1 $aa bb$
	green	yellow	blue	white

15. At least one copy of the dominant B allele is needed to produce blue pigment in the feathers. At least one copy of the dominant A allele is needed to produce yellow pigment in the feathers. If a bird produces both yellow and blue pigment in the feathers ($A- B-$), then the feathers are green.
16. 2 short-fingered rollers: 1 long-fingered roller: 2 short-fingered non-roller: 1 long-fingered roller.
17. a) In the F2: black: $A- B-$ and $A- bb$; gray: $aa B-$; white: $aa bb$
b) Black parent: $AA BB$; white parent: $aa bb$
18. All female offspring will be barred. All male offspring will also be barred
19. c
20. A sex-linked trait is determined by a gene on one of the sex chromosomes. A sex-influenced trait is determined by an autosomal gene, but the phenotype also depends on the individual's gender
21. Fragile-X syndrome and Huntington's disease.