BIO 181 Lab
Spring 2014

Name:

Mendelian Genetics Problems

1) Do your own work. These problems are similar to what will occur on the second lecture exam, final exam and lab quizzes. Do not share or work with others since you cannot do this on the exams.

2) Make sure to write your final answer in the boxes, but feel free to use the rest of the page for calculations. Whenever you are determining the results of a cross, write out the Punnett Square!

3) When you assign letters to alleles, make sure to choose letters that look clearly different in upper and lower case. Also make sure you know which is the dominant and recessive allele and phenotype.

1.   In humans, a free earlobe is the dominant trait and an attached earlobe is the recessive trait. Both parents are heterozygous.

a) What are their phenotypes?

a) Mother's phenotype:_____
    Father's phenotype:_____

b) What is the probability of this couple having a child **with attached earlobes**?

b) _____%

c) What is the probability of this couple having a child **with free earlobes**?

c) _____%

2. a) If you know that an individual has the phenotype of free earlobes, you also automatically know their genotype.

a) True   or   False

b) Draw two possible Punnett squares for a cross between two individuals with free earlobes.

Punnett square 1:	Punnett square 2:

3. In certain breeds of cattle, color is inherited by genes that have incomplete dominance. In such bovine, a cross between a homozygous red bull and a homozygous white cow will always result in a roan (light red) calf. A cross is made between one roan and one red cattle. What is the expected phenotypic ratio of the colors red, roan and white appearing in the offspring?

Phenotypic ratio:
____red :   ____roan :   ____white

4. Tail feather color in the Phoenix bird is dictated by interactions among alleles of two gene pairs (epistasis). For one gene pair, black (B) feather color is dominant to brown (b), but another gene determines if any melanin pigment is deposited in the feather shaft. Two recessive alleles (ee) of this gene block deposition, and a yellow feather results. Determine the coat color **of each** Phoenix bird genotype given.

Phenotype (feather color black, brown, or yellow):
a) BbEE_____
b) BBee_____
c) Bbee_____
d) bbEe_____

5. In humans, the allele for type A blood and the allele for type B blood show codominance. A person with both alleles has blood type AB. Both A and B dominate type O. Blood types are determined by the type of sugar molecule added to the surface of the red blood cells. The letter for the gene encoding the enzyme that can add this sugar is often designated I. Often the A and B alleles are written as a superscript to the dominant, upper case I: I^A and I^B. The recessive allele, lowercase i, codes for an enzyme that does not add a sugar molecule at all, resulting in Type O blood.

A person with an allele for type B blood and an allele for type O blood marries someone with an allele for type A blood and type B blood.

a) Draw a Punnett square for this cross

a) Punnett square:

b) List the probability of each blood type in their offspring.

b) the probability of blood type
A = _____ %
B = _____ %
AB = _____ %
O = _____ %

6. For this problem, use the information given in Question 5. A woman with type B blood gave birth to a baby with type O blood. In a court case, she claims that a certain man is the father of her child. The man has type A blood. Could he be the father?

a) If these two individuals had offspring, which blood types would be possible?

a) Circle all that apply
A,   B,   AB,   O

b) Based on this information alone, you could **prove** that the man is the father.

b) Circle one: True   or   False

7. In dutch belted rabbits, black (B) color dominates brown (b) color. The floppy ear (L) dominates the upright (l) ear. A cross is made between two rabbits bbLl x Bbll.

a) Draw a Punnett square of the cross.

a) Punnett square:

b) List the phenotypic ratio.

b) Phenotype ratio:

__Black Floppy : ___Black Upright : ____ Chestnut Floppy : __Chestnut Upright

8. This question is based on the information in question 7. If two Black Floppy rabbits, who are heterozygous for both traits are crossed, what is the phenotypic ratio of the possible offspring?

Phenotype ratio:

___Black Floppy : ___Black Upright : ____ Chestnut Floppy : __Chestnut Upright

9. In humans, the condition for normal color vision (H) dominates the condition for colorblindness (h). **Both alleles are linked to the X chromosome.** In humans, females are XX while males are XY; sex-linked traits can be written as a superscript of the sex chromosome to which they are linked. In this case: X^H or X^h. A male with color vision marries a woman who is a carrier for this color blindness. (In this respect, a carrier is a woman who has an allele for normal vision and an allele for color blindness.)

a) Draw a Punnett square for this cross.

> a) Punnett square:

b) What is the probability that if they have a **<u>female</u>** child, she will have normal color vision?

> b) Probability:
>
> _____%

10. For this problem use the information given in question 9. A girl has color vision, and so do both her parents. Her maternal grandfather however was color blind.

a) What are the genotypes of her parents?

> a) Genotypes
>
> Father _____
> Mother_____

b) What is the probability that the girl is a carrier?

> b) Probability
>
> _____%

Using the Chi-square goodness of fit test.

Example A: A research plant geneticist is studying flower color in peas. The scientist crosses a true breeding purple plant with a true breeding white plant and raises the offspring, all of which are purple. The scientist then allows one of the purple F_1 plants to self-pollinate, and raises all the resulting seeds. The scientist counts 312 purple flowered plants and 90 white flowered plants. Does this gene follow a Mendelian pattern of inheritance?

First, calculate how many purple and white flowered plants you would expect. Using B for the purple allele and b for the white allele in a Punnett square, it is determined that 3/4 of the plants should have purple flowers and 1/4 of the offspring have white flowers. Review the Punnett square below:

Gametes	B	b
B	BB	Bb
b	Bb	bb

Since there were 402 total plants (312 purple + 90 white), one would expect 301.5 (402*3/4) to be purple and 100.5 to be white (402*1/4). Next, use the observed and expected values to calculate a test statistic with the following formula:

$$X^2 = \Sigma \ \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

For this problem, the following would be calculated:

$$X^2 = \frac{(312 - 301.5)^2}{301.5} + \frac{(90 - 100.5)^2}{100.5}$$

$$= 1.46$$

This is compared to a chi-square distribution at 5% with one less degrees of freedom than the number of categories in the analysis. Since there are two categories (purple and white), there is one degree of freedom. The critical value of the Chi-square distribution for one degree of freedom is 3.84. Since your test statistic is less than this, you have no reason to reject an hypothesis of Mendelian inheritance. You can also use Excel to gain a p value for the problem. The p value is the probability of getting your data if your expectations are correct. For this data, a p value of 0.227 was calculated. Since it is not below 5%, you would fail to reject the hypothesis of Mendelian inheritance for this trait.

Example B: The research scientist in the previous question is now interested in whether the flower position gene (axial vs. terminal) and the flower color gene are inherited in a Mendelian fashion. The scientist crosses a pea plant that is true breeding for purple, axial flowers and a pea plant that is true breeding for white, terminal flowers. The scientist then takes one of the purple, axial flowered offspring and allows it to self-pollinate. The scientist raises the seeds from the plant and gets the following offspring:

Purple axial	133
Purple terminal	52
White axial	49
White terminal	18

Do these genes follow a Mendelian pattern of inheritance?

First, calculate how many purple axial, purple terminal, white axial and white terminal flowered plants you would expect. Using B for the purple allele and b for the white allele and A for the axial and a for the terminal flower position in a Punnett square, it is determined that 9/16 of the plants should have purple axial flowers, 3/16 should have purple terminal flowers, 3/16 should have white axial flowers and 1/16 of the offspring should have white terminal flowers. Review the Punnett square below:

Gametes	BA	Ba	bA	ba
BA	BBAA	BBAa	BbAA	BbAa
Ba	BBAa	BBaa	BbAA	Bbaa
bA	BbAA	BbAa	bbAa	bbAa
ba	BbAa	Bbaa	bbAa	Bbaa

Purple axial (B_A_): 9
Purple terminal (B_aa): 3
White axial (bbA_): 3
White terminal (bbaa): 1
Total: 16

Since there were 252 total plants (133 purple/axial + 52 purple/terminal + 49 white/axial + 18 white/terminal), one would expect 141.75 (252*9/16) to be purple/axial, 47.25 (252*3/16) to be purple/terminal, 47.25 (252*3/16) to be white/axial and 15.75 (252*1/16) to be white/terminal. Next, use the observed and expected values to calculate a test statistic with the following formula:

$$X^2 = \Sigma \ \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

For this problem, the following would be calculated:

$$X^2 = \frac{(133-141.75)^2}{141.75} + \frac{(52\text{-}47.25)^2}{47.25} + \frac{(49\text{-}47.25)^2}{47.25} + \frac{(18-15.75)^2}{15.75}$$

$$= 1.40$$

This is compared to a chi-square distribution at 5% with one less degrees of freedom than the number of categories in the analysis. Since there are four categories (purple/axial, purple/terminal, white/axial and white/terminal), there are three degrees of freedom. The critical value of the Chi-square distribution for three degrees of freedom 7.81. Since your test statistic is less than this, you have no reason to reject an hypothesis of Mendelian inheritance. You can also use Excel to gain a p value for the problem. The p value is the probability of getting your data if your expectations are correct. For this data, a p value of 0.705, or 70.5% was calculated. Since it is not below 5%, you would fail to reject the hypothesis of Mendelian inheritance for this trait.

11. A research geneticist is trying to determine if the vestigial wing gene in fruit flies is inherited in a Mendelian fashion. The scientist breeds a true breeding normal winged fly with a true breeding vestigial winged fly. The scientist then lets the F_1 generation freely breed offspring, and counts the number of normal and vestigial winged offspring produced. The following numbers are recorded: 985 winged flies, 278 vestigial winged flies. Is this gene inherited in a Mendelian fashion?

Degrees of freedom: _____ Test statistic: _____ Chi-square critical value: _____		
Is this gene inherited in a Mendelian fashion (circle one)? Yes No		

F_1 generation freely breed. The offspring are then described and counted, with the following results: 413 normal wing/amylase, 127 normal wing/no amylase, 119 vestigial wing/amylase, 42 vestigial wing/no amylase. Is this gene inherited in a Mendelian fashion?

Degrees of freedom: _____ Test statistic: _____ Chi-square critical value: _____		
Is this gene inherited in a Mendelian fashion (circle one)? Yes No		