Genetics Problem Solving

Please bring your textbook to this laboratory session.

A. Objectives

Become familiar with
1. Probability calculations
2. Solving genetics problems

B. Before lab

3. Read *The laws of probability govern Mendelian inheritance* on pp. 269-271 in your textbook.
4. Read *Tips for Genetics Problems* on page 283 of your textbook.

C. During lab

In groups of four, work through the genetics problems.

D. After lab

1. Review the chi square exercise (Appendix E).
2. Practice solving genetics problems (e.g., end of the chapter 14 problems in Campbell et al.).
3. If you feel you need more help solving genetics problems, check out this site: http://www.ndsu.nodak.edu/instruct/mcclean/plsc431/mendel/mendel1.htm

Predicting the outcome of various crosses

1. A female carrier of Tay-Sachs wants to have a child with a male carrier for Tay-Sachs. Tay-Sachs is inherited in an autosomal recessive manner. Using the letters "T" and "t" fill out the following table.

	Female	Male
Genotype		
Phenotype		
Genotypes of sperm/ova		

2. Determine the probability of them having a child with Tay-Sachs using a Punnett square (page 192).

3. You can also calculate the probability. This is especially convenient when looking at more complex characters (imagine a Punnett square for a trihybrid cross!).

The probability (P) scale ranges form 0 to 1.
The probabilities for all possible outcomes for an event must add up to 1.

Event	Probability (%)
Tossing heads with a 2-headed coin Tossing tails with a 2-headed coin	
Tossing heads with a normal coin Tossing tails with a normal coin	
Rolling 3 on a 6-sided dice Rolling a number other than 3	

4. You have just rolled three threes in a row. What is your chance of rolling another 3?

5. In the Tay-Sachs example above, the probability of receiving the "t" allele from the mother is independent of the probability to receive a "t" allele from the father. Apply the rule of multiplication:

P of egg receiving "t"	P of sperm receiving "t"	P of offspring "tt"

6. A child heterozygous for Tay-Sachs can inherit the two alleles in two independent ways: By receiving the "t" from the mother and the "T" from the father, or the "t" from the father and the "T" from the mother. Apply the rule of addition to calculate P of "Tt".

P of "t" in egg and "T" in sperm	P of "T" in egg and "t" in sperm	P of “Tt”

7. Now consider the following cross of garden peas: PpYyRr x Ppyyrr, where

Character	**Trait and genotype**
Flower color	Purple: Pp, PP White: pp
Seed color	Yellow: YY, Yy Green: yy
Seed shape	Round: RR, Rr Wrinkled: rr

Use the table below and list the genotypes and phenotypes of the offspring of the above cross that are homozygous recessive for at least two out of the three traits.
Hint: This is not your standard trihybrid cross. You should find five different genotypes.

Genotype	Phenotype

8. Use the table below to calculate the probability for the offspring of PpYyRr x Ppyyrr to exhibit each of the above phenotypes
   Hint: use the rule of multiplication.
9. Use the rule of addition to calculate the probability that the offspring would have one of the five genotypes.

Genotype with at least two homozygous recessives	Probability of genotype
Probability that offspring has any of these:	

Mendelian Genetics Practice Problems

(1) Start with reviewing the list of all the inheritance patterns discussed in class (*hint: this list can also serve as an outline for the essay question for chapter ten*). Make sure that you know examples for each pattern. These patterns are

1. Mendelian inheritance (complete dominance)
2. Incomplete dominance
3. Co-dominance
4. Epistasis
5. Autosomal linkage
6. X-linked dominant/recessive
7. Y-linked
8. Epistasis

9. A pattern that we have not discussed is that certain combinations of alleles could lead to abortion (lethal), which will change the ratio of expected phenotypes in the offspring generation.

(2) For the individual problems below, start with figuring out the genotype of the parent generation, based on the phenotypes of the F_1 an F_2 generations.

(3) Then propose hypotheses about the type of inheritance that is consistent with the data in each problem and explain the rationale of your choice.

Example

Note: Cross 1 and 2 in example a) are connected. B) gives you a new set of parents

- a) cross 1: red-eyed mouse **X** white-eyed mouse
  gives F1: all red-eyed

Pretty obvious, isn't it? The hypothesis that the parents are true-breeding for red and white eyes respectively, and that white is recessive to red fits the data and Mendel's predictions.

cross 2: red-eyed F1 **X** red-eyed F1
gives F2:
36 red-eyed
13 white-eyed

Again, the data pretty much fit the expected ratio of Mendelian inheritance for the F2 generation (3:1). But wait a minute – is "pretty much fit" good enough? We have to consider the relatively small sample size and next lab, we'll run some statistics to figure out when "pretty much" is good enough.
Conclusion: this is most likely an example of Mendelian inheritance with red eyes being dominant over white eyes.

- b) cross 1: long-eared mouse **X** short-eared mouse
  gives F1:
  12 long-eared
  10 short-eared

This can't be your standard monohybrid cross, because you do not get a 1:0 ratio. From the data, it's not clear either, whether one trait (and which) is dominant over the other. Look at cross 2 to see whether it sheds some light.

cross 2: long-eared F1 **X** long-eared F1
gives F2:
36 long-eared
13 short-eared

Aha! Now it looks Mendelian again, like a regular cross of two hybrids, with long-eared being dominant over short-eared (the telling 3:1 ratio). So what was going on in b) cross 1? See how useful it is to consider the parent generation?

1. Flowers

cross 1: blue-flowered plant **X** white-flowered plant
gives F1: all pale-blue-flowered

cross 2: pale-blue F1 **X** pale-blue F1
gives F2:
27 blue
49 pale-blue
24 white

1. **Blood Type** (note the notation for bloodtypes: I^A for the A marker, I^B for the B marker and i for no marker)

a) cross 1: person with type A blood **X** person with type B
gives F1: all type AB blood

cross 2: type AB F1 **X** type AB F1
gives F2:
2 type A
4 type AB
1 type B

b) cross 1: type A blood **X** type B
gives F1:
2 type A blood
3 type AB blood
1 type B blood
2 type O blood

2. **Mice II**

cross 1: tail-less mouse **X** normal mouse
gives F1:
10 tail-less
9 normal

cross 2: tail-less F1 **X** tail-less F1

gives F2:
10 normal
21 tail-less
9 dead

3. **Flies**

cross 1: red-eyed female **X** red-eyed male
gives F1:
50 red-eyed female

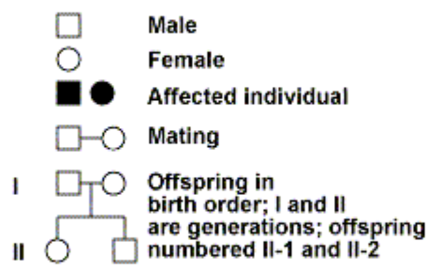
25 red-eyed male
25 white-eyed male

cross 2: white-eyed male F1 **X** red-eyed female F1
52 crosses give:
30 red male
33 red female

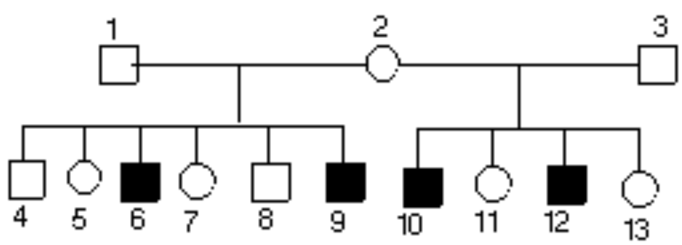
48 crosses give:
22 red male
24 red female
21 white male
23 white female

5. Pedigrees

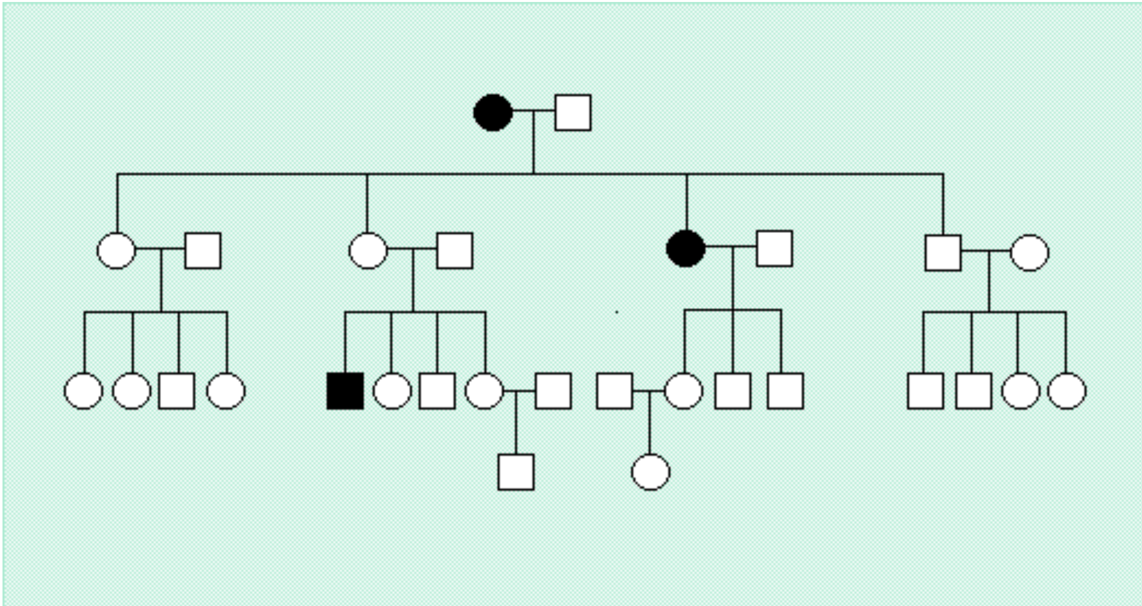
Explanation of symbols used in the pedigrees below:



a) What is the probable type of inheritance?



b) What is the probable type of inheritance?



6. Mice III

a) cross 1: blue-eyed, long-toothed mouse **X** brown-eyed, short-toothed mouse
gives F1: all blue-eyed, short-toothed

cross 2: blue-eyed, short-toothed F1 **X** blue-eyed, short-toothed F1
gives F2:
92 blue-eyed short-toothed
31 blue-eyed long-toothed
29 brown-eyed short-toothed
9 brown-eyed long-toothed

(NOTE how this result is different from the blood-type result because here we are dealing with two genes and there we were dealing with multiple alleles of one gene.)

b) cross 1: tall, green plant **X** short, yellow plant
gives F1:
20 tall green
20 short green

cross 2: tall, green **X** short, yellow (different plants than (b))
gives F1:
19 tall green
21 tall yellow

7. Pathways I

a) Assume the following pigment-producing pathway in a plant:

enz A enz B
compound 1 ------> compound 2 --------> compound 3
(colorless) (red) (purple)

Also assume that the A and B alleles produce functional enzyme, while the a and b alleles produce no functional enzyme. Assume that one functional copy of an enzyme is sufficient to catalyze the reaction.

cross 1: AaBb **X** AaBb

predict the colors of the progeny.

b) What if the pathway were:

enz B enz A
compound 1 ------> compound 2 --------> compound 3
(red) (colorless) (purple)

c) Assume two parallel pigment pathways:

enz A enz B
red pigment <----colorless compound ------> blue pigment cross

1: Aabb **X** aaBb
gives F1:
33 white
32 red
35 blue

8. Linkage:

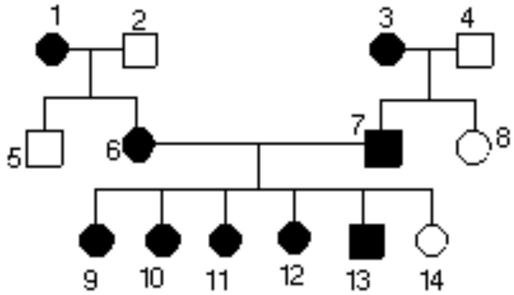
cross 1: rough, soft pea **X** smooth, hard pea

gives F1: all rough, hard

cross 2: rough, hard F1 **X** smooth, soft (**note:** different mating than usual)

gives F2: 115 rough soft
110 smooth hard
8 rough hard
12 smooth soft

9. A pedigree that illustrates multiple possible models is:



10. A man with a Y-linked disorder has three sons and three daughters by the same mother. His first son has two sons and two daughters by another woman. Draw the pedigree for this family. How could you tell if this disorder was Y linked or sex-linked recessive?

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