Bio 213 GENETICS (Fall 2000)
Problem Set 6: Mendelian Genetics

Questions relating to Mendel's experiments and c^2 tests

PS6.1. A plant that is heterozygous for two independently assorting recessive mutations is self-crossed:

    a. How many phenotypes would you expect, and in what ratio?
    b. How many genotypes would you expect, and in what ratio?

PS6.2. Brooker, Chapter 2, problem 12 (note: see answers to problems in the book).

PS6.3. In the 19th century, the new theory of evolution was criticized on grounds that if an advantageous variant trait happened to appear in a population, the individual carrying the trait would only be able to mate with less fit individuals. These progeny would almost certainly also mate with less fit individuals, and so on. With time, the trait would be diluted out. Darwin himself admitted he did not know how to refute this objection. Do you?

PS6.4. The table to the right contains the results of a dihybrid cross of a strain that is AaBb. Fill in the six empty boxes and explain the significance of the table.

1	2	1
2	4	2
1	2	1

PS6.5. The table to the right contains the results of a dihybrid cross of a strain that is AaBb. Fill in the six empty boxes and explain the significance of the table.

PS6.6. Brooker, Chapter 2, problem 22

PS6.7. Suppose instead of flies, we did peas. So there you are, trying to replicate Mendel's work in half a semester. One of your mystery plants breeds true and produces round green seeds and another, which also breeds true, produces wrinkled yellow seeds. You cross these two plants and all the progeny produce round yellow seeds. A self cross of these progeny give F_2 progeny in the following phenotypes:

        Round Yellow   255 seeds
        Round Green   126 seeds
        Wrinkled Yellow   123 seeds
        Wrinkled Green   5 seeds

    a. Which phenotypes appear dominant?
    b. What major conclusion can you make from this data?

**PS6.8. Back to fly reality. Every once in a great while you notice a fly that has a golden body color. Early one morning, you have the great fortune of finding two such flies: one a male, and the other (in another culture) a virgin female. Delighted, you cross one with the other and are blessed with 48 progeny: 34 golden and 14 normal color.

> a. Which trait do you think is dominant: golden or normal color?

> b. What do you think are the genotypes of the parents and their progeny?

> c. What phenotypic ratios would you have expected from your answers to **a** and **b**? Perform a χ^2 test of your hypothesis.

> d. How could you test your answer to **b** by genetic crosses?

> e. Suppose you perform several individual crosses of a golden progeny to a wild-type fly and find that invariably the resulting brood includes both golden and normal progeny in roughly equal amounts. Think of a couple of explanations for what you've found thus far.

> f. One hypothesis you might think of in PS6.5e requires you to reexamine the numbers you got in the cross of the original golden flies. Do another χ^2 test based on this new hypothesis

> g. What do your results say about the predictive powers of χ^2 tests?

PS6.9. You are a practicing hematologist who has 25 patients who have come to you because of complaints associated with sickle cell anemia, an autosomal recessive disorder. In examining the families of these patients, you find that all parents have a normal phenotype, and the families have a total of 165 children, of which 60 have sickle cell anemia. (If you're going to be a practicing physician, you'd better become familiar with this type of situation)

> a. What number of affected children out of 165 would you have expected?

> b. Use the χ^2 test to determine whether the actual results makes your hypothesis unlikely.

> c. How do you account for the actual results?

Questions relating to Mendelian genetics and probabilities

PS6.10. Brooker, Chapter 2, Solved problems 1 and 2

PS6.11. Brooker, Chapter 2, problem 18.

PS6.12. Use the rules of addition, multiplication, and complementarity to come up with a probability for each of the following situations, based on the probabilities of its component parts. Try to break the statement down to its simplest elements. Note that the answers will not contain actual numbers but rather symbolic statements of the type: "You are a man or a mouse" translates to P(you are a man) + P(you are a mouse).

a. A seed is wrinkled and yellow
b. An Aa x Aa cross gives a homozygous progeny
c. A progeny from an AaBb x AaBb cross is homozygous at both alleles
d. A blind date is one of the following: tall, dark, handsome
e. No one at UR has Purple Tongue Syndrome
f. A child is taller than his father and taller than his mother
g. A person will suffer a severe allergic reaction from taking an antibiotic.
   Consider that:
   - A fungal compound contaminates some batches of the antibiotic.
   - Most people have no allergic reaction to the compound.
   - Allergic individuals exposed to the compound sometimes suffer a
     severe reaction but sometimes do not.

PS6.13. Suppose three different genes, D, E, and F, all unlinked to each other, are known to control the predisposition towards heart disease. Using the P() notation to show how you would calculate the probabilities requested below. (Example: "Probability that a person is mutant in D" translates to "P(D-)".

a. Suppose that a person is predisposed only if all three loci are mutant.
   What is the probability of that occurring?

b. Suppose that a person is predisposed if any of the three loci are mutant.
   What is the probability of that occurring?

c. Suppose is the probability that a person is not mutant in D?

d. Suppose that a person is not mutant in all three loci?

e. If you couldn't figure out b, try it again, using d as a starting point.

PS6.14. Brooker Chapter 2, problem 16, Solved problem 3, problem 20

PS6.15. What is the probability that a two children conceived separately from each other are identical twins. (Assume no recombination and forget about clones and such)

PS6.16. The consanguinity factor is the degree to which to individuals are likely to share the same genes. It is of importance in assessing the risk of producing rare homozygous recessive traits in progeny of incestuous or otherwise consanguineous unions. It's also interesting for its own sake. You can think of the factor as the probability that some rare gene in one person is carried by a second. For example, the consanguinity factor between parent and child is ½: you have half of your father's genes and half of your mother's. Determine the consanguinity factor for the following relationships:

a. Two siblings
b. Two first cousins
c. Uncle-niece or aunt-nephew
d. First cousins (both sets of grandparents the same)
e. First cousin once removed (e.g. child of first cousin)

PS6.17. In many cultures, male children are so valued that couples will continue to have children until they get one. Take the extreme case where all couples in a population have children until they get a male child, and then they stop. What is the male:female ratio in the population that results from this practice?

Questions relating to other matters of interest

You won't be examined on the following types of questions, at least not for several years, but knowing how to answer them is by itself probably worth the price of tuition.

PS6.18. You have two siblings. Your sister has two children and your brother none. You have two children. A week hardly passes by that your mother doesn't rag on you to have more. It doesn't work to say, "Aren't two enough?", so you're ready to try another approach. Look at things from her point of view, presuming, of course, that her primary interest is in perpetuating her genes in future generations.

  a. Calculate what fraction of her genome was passed on to your own generation. (Assume that all genes assort independently).

  b. Calculate what fraction of her genome has thus far been passed on to your children's generation.

  Now you understand why she is concerned. Nonetheless, you have many arguments in your favor.

  Trivial Difference Strategy: Calculate what percent increase in genome transmitted would result by your having another child.

  Not-my-fault-ma Strategy: Calculate what percent increase in genome transmitted would result by your brother having a child.

  Hey-what-about-you Strategy: Calculate what percent increase in genome transmitted would result (in your generation) by your mother having another child.

PS6.19. You may already be a Winner!!! For just one dollar you can buy a card with ten numbers from 1 to 1000. Ten winning numbers from 1 to 1000 will be selected at random. If you match any three of them, you get one million dollars! Imagine, you lose seven times and you're still a millionaire! Hey, can you walk away from this one?

  a. What are your odds of winning?
  b. What is your expected gain? [gain = (odds of winning · (prize) - (cost)]
  c. Where do they get these games anyway?