

NAME \_\_\_\_\_ TA \_\_\_\_\_

## 7.013 Spring 2005 Problem Set 2

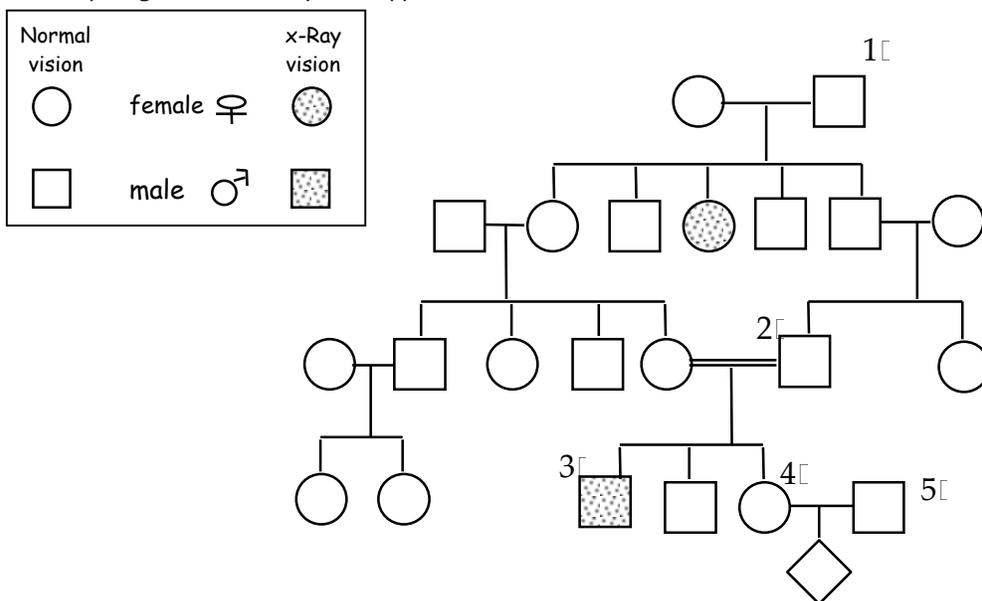
FRIDAY February 18, 2004

**Problem sets will NOT be accepted late.**

### Question 1

The following family was used to study the transmission of a gene responsible for a rare trait. Since the trait is 'rare', assume that people marrying into the family have 2 normal alleles for the gene of interest in this case.

This family was found to carry the rare allele manifesting in the ability to see through walls ("x-Ray vision"). The pedigree for this phenotype follows.



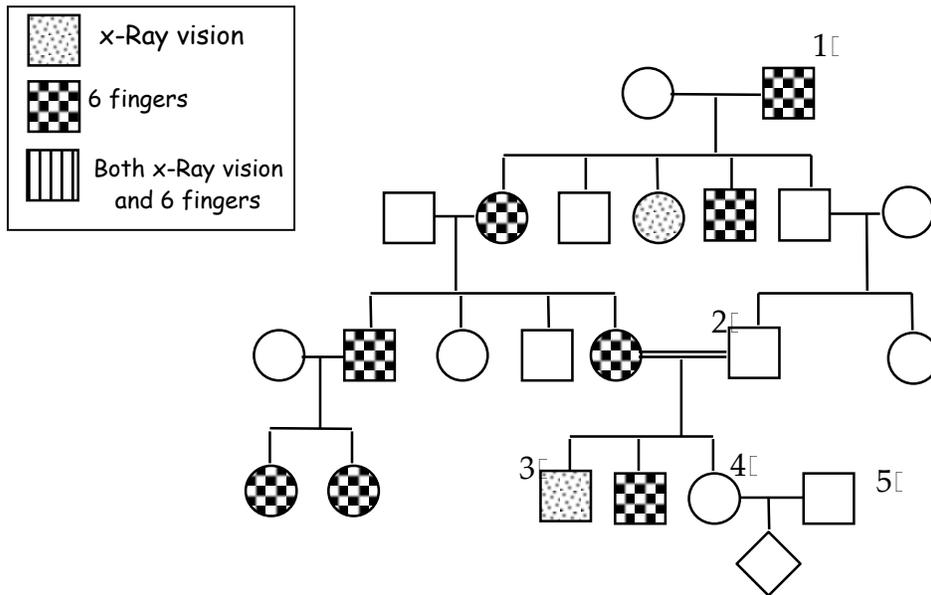
a) What is the most likely mode of inheritance? (Choose from: autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive, Y-linked dominant, and Y-linked recessive, or mitochondrial inheritance.)

b) Use "R" and "r" for the x-Ray vision alleles. Use the capital letter for the allele conferring the dominant phenotype and include sex chromosomes if appropriate. What is the genotype of individual 2?

c) What is the genotype of individual 3?

d) If individual 4 marries individual 5, what is the probability that their child will be heterozygous at the locus of interest? Show your work.

Amazingly (and conveniently), the **same** family carries the rare allele for having 6 fingers. The inheritance pattern follows. The inheritance patterns for both the 6-finger phenotype and x-Ray vision are illustrated in the following pedigree.

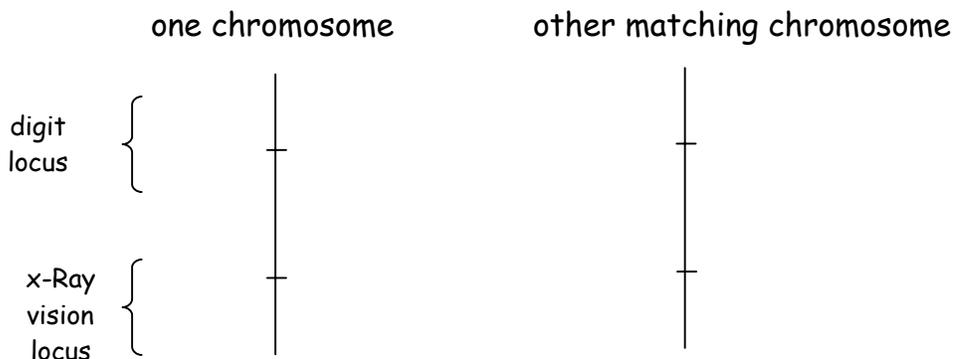


e) What is the most likely mode of inheritance for the allele causing the 6-finger phenotype? (Choose from: autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive, Y-linked dominant, and Y-linked recessive, or mitochondrial inheritance.)

f) If the genes conferring x-Ray vision and having 6 fingers are linked, what alleles of the two genes are found on each chromosome of individual #1, IF NO recombination occurs,?

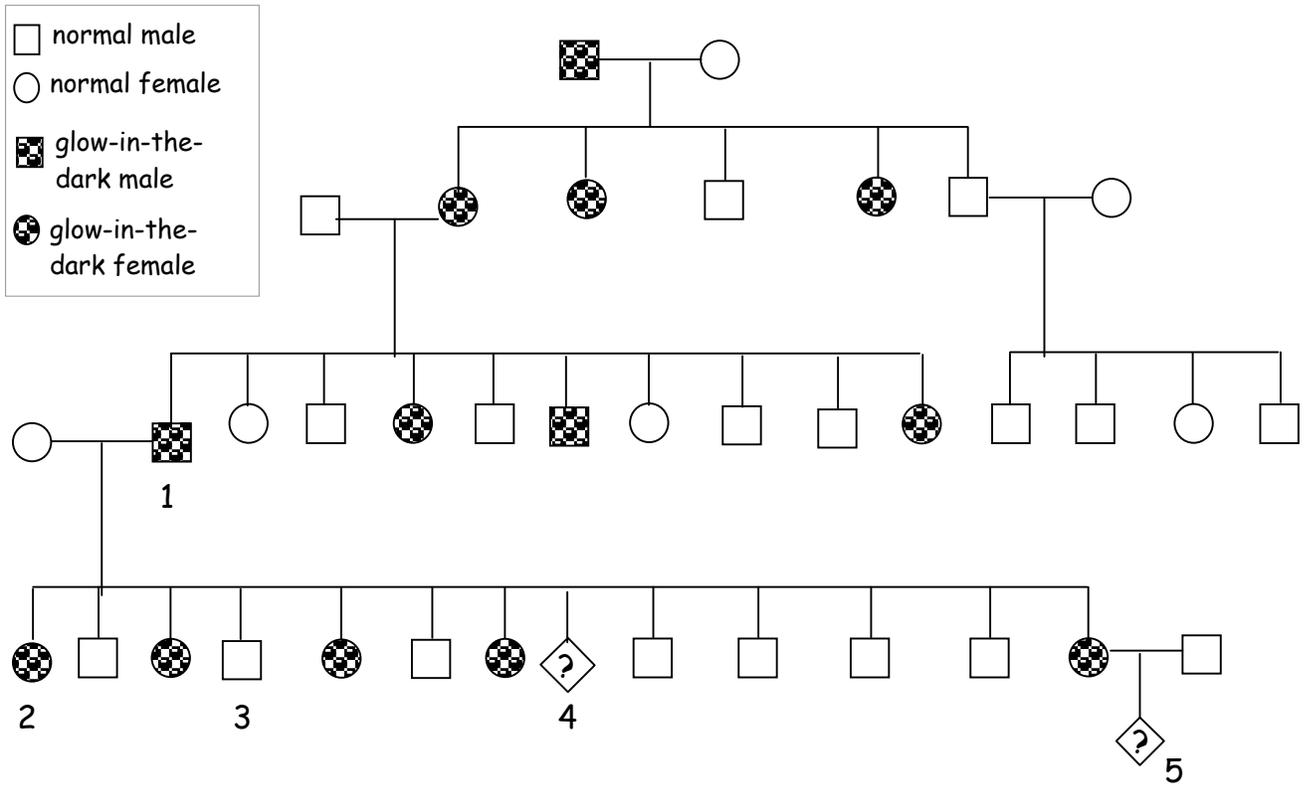
Use "D" and "d" to describe the alleles of the finger or Digit locus.  
 Use "R" and "r" to describe the alleles of the x-Ray locus.  
 Use the capital letter for the allele conveying the dominant phenotype.  
 Place the alleles for each locus on the chromosomes shown below.  
 Indicate whether the chromosomes below are sex chromosomes.

Individual #1



Question 2

Near the halls approaching the BioCafe, you discover a colony containing amazing never before seen glow-in-the-dark cockroaches. Curious as to how this trait is inherited, you observe the progeny descended from one particular glow-in-the-dark cockroach over several generations.



a) What is the most likely mode of inheritance of the glow-in-the-dark trait? (Choose from: autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive, Y-linked dominant, and Y-linked recessive, or mitochondrial inheritance.)

b) Using "R" for the dominant allele and "r" for the recessive allele, and sex chromosomes if appropriate, what is the genotype of:

Cockroach # 1? \_\_\_\_\_ Cockroach # 2? \_\_\_\_\_ Cockroach # 3? \_\_\_\_\_

c) What is the probability that Cockroach # 4 will glow in the dark?

If male \_\_\_\_\_ If female \_\_\_\_\_

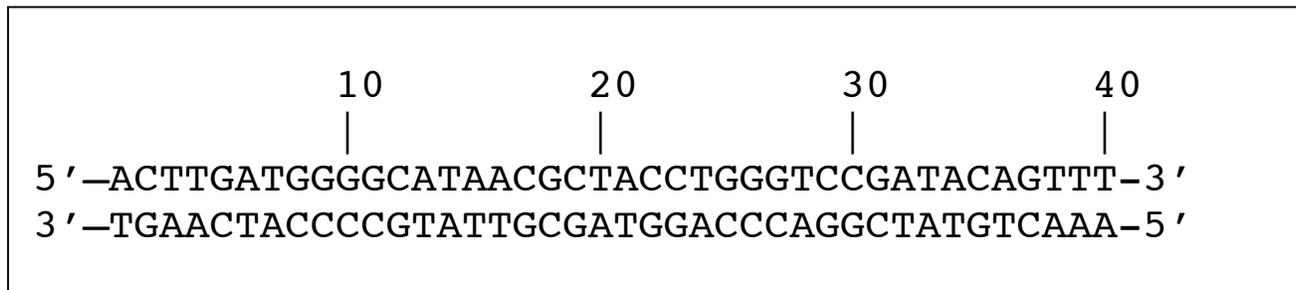
d) What is the probability that Cockroach #5 will glow in the dark?

If male \_\_\_\_\_ If female \_\_\_\_\_

### Question 3

In the year 2012, a Mars probe sends a Martian soil sample back to Earth. Your lab is chosen to study an organism found alive in this sample! The organism contains DNA that uses the same 4 deoxyribonucleotides (dGTP, dATP, dTTP, and dCTP) that earth organisms use. You isolate the Martian DNA polymerase so you can study DNA replication in this organism.

You use Martian DNA polymerase, a short DNA primer (5' **ACCCAG** 3') (DNA primers work as well as RNA primers) and the 4 deoxyribonucleotides to replicate the following double stranded DNA template.



a) In what direction does DNA polymerization occur on Earth?

3'→5'

C→N

5'→3'

N→C

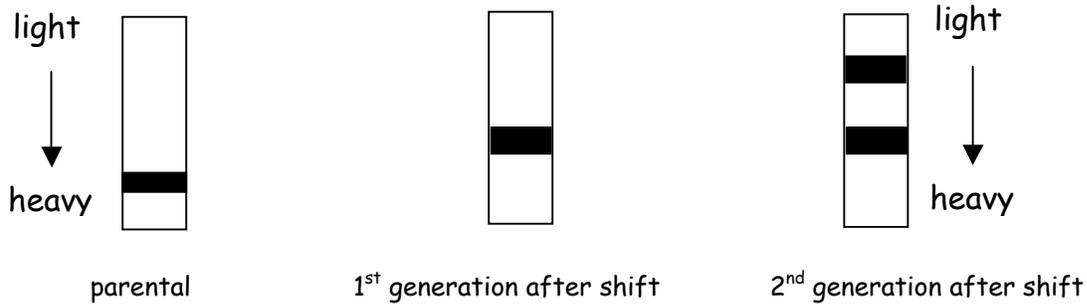
b) If the Martian DNA polymerase synthesizes DNA in the 5' to 3' direction, write the resulting DNA sequences and indicate the polarity (5' and 3') and the lengths (in nucleotides) of the daughter strand(s) on the figure below.

5' -ACTTGATGGGGCATAACGCTACCTGGGTCCGATACAGTTT- 3'

3' -TGAACTACCCCGTATTGCGATGGACCCAGGCTATGTCAA- 5'

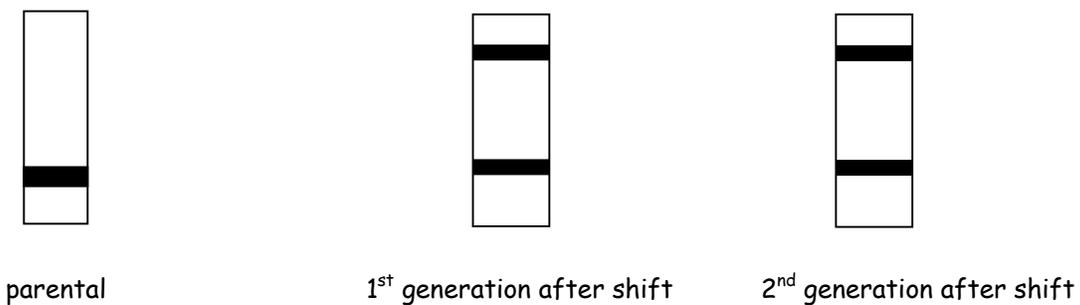
c) Based on your answer and the primer provided, will you be able to fully replicate the Martian DNA boxed above? If no, explain why not.

c) Meselson and Stahl demonstrated that *E. coli* replicates in a distinct manner. (See textbook, pgs 221-222.) This was shown by first growing *E. coli* in medium containing  $^{15}\text{N}$  for the first few generations, shifting the culture to medium containing to lighter  $^{14}\text{N}$  and then examining the density of the next generation of DNA. Their results are shown below.



i) What manner of replication did they observe? Conservative, Semi-conservative or Dispersive?

ii) You perform the same kind of experiment with your Martian organism and you get the following results. What manner of replication is this? Conservative, Semi-conservative or Dispersive?



#### Question 4

While working in the lab late one night, you notice something about the mice that live behind the freezers: Most of the mice are black, but there are rare cases of white mice. You capture two white mice and two black mice, and breed black with black and white with white. You find that all of the offspring of the black mice are black, and all of the offspring of the white mice are white. You find these strains to be *pure* or *true breeding*, that is to say all subsequent generations resemble their parents with respect to fur color.

a) One of the white males gets tired of the local scene and sneaks out of his cage and into a cage full of black females. The next morning, you find him sleeping in the corner. After putting him back into his own cage, you notice that all 10 of the females in the cage are now pregnant! Interestingly, all 100 offspring fathered by the white male are completely black. You think: "Hmmm, this could be explained if white coat color is a recessive trait. I'll call the dominant coat color allele 'B' and the recessive allele 'b'." List all relevant genotypes and phenotypes of the original parents, denoted P and the offspring, denoted F<sub>1</sub>.

b) In order to test your hypothesis, you take 10 pairs of the offspring (F<sub>1</sub>) from the above cross, and mate them to each other, to produce 100 new offspring (F<sub>2</sub>). If your hypothesis is correct:

i) What fur colors will you see in the F<sub>2</sub> generation?

ii) What are the corresponding genotypes?

iii) Roughly how many mice of each genotype and phenotype do you expect to see of the 100 F<sub>2</sub> progeny? Show your work.

c) Another student in the lab, who happens to be your academic rival, notices that all of the white mice from which the male in the P generation came have red eyes, while all of the black mice from the P generation have green eyes. Examining the F<sub>1</sub> mice, he notices that they are all black, AND all have green eyes. He proclaims loudly that he has figured it out! The same mutation that causes white fur causes red eyes. Begrudgingly, you admit that it is a good idea.

If he is right, what are the genotypes and phenotypes of the F<sub>2</sub> mice with respect to eye color and coat color?

d) Triumphantly, you realize that there is another explanation: There could be 2 separate recessive mutations on different chromosomes; one causing white coat color and one causing red eyes. You decide to call the allele causing red eyes 'g', and the allele causing green eyes 'G'. If your hypothesis is correct:

i) What classes of genotype will you see in the F<sub>2</sub> mice? List their corresponding phenotypes.

ii) Approximately how many mice of the 100 progeny do you expect to see, of each **phenotype**? (A Punnett square may aid your calculation.)

### Question 5 (continuation of previous question)

When the two of you stop bickering and go and check out the 100  $F_2$  mice, you are both shocked to find that neither of you predicted the right proportions! What you observe is somewhere in between your two guesses. In order to relieve any ambiguity, you decide to do a *test cross*. That is to say that you cross  $F_1$  females to males identical to the male escapee in the P generation (from Question 3).

From this cross, you get:

- 46 mice with black fur and green eyes,
- 45 mice with white fur and red eyes,
- 4 mice with black fur and red eyes,
- 5 mice with white fur and green eyes

a) Propose a new theory as to what is most likely to be causing these strange proportions.

b) Can you determine how far apart are the eye and fur color genes in cM?

- i) No, not enough information given to determine whether they are linked.
- ii) No, they are not linked.
- iii) Yes, my calculation is shown below. (Calculate below.)

I claim that the work on this problem set is my own. ← Please copy this statement and sign your name.