

7.013 Spring 2005 Problem Set 2 Solutions

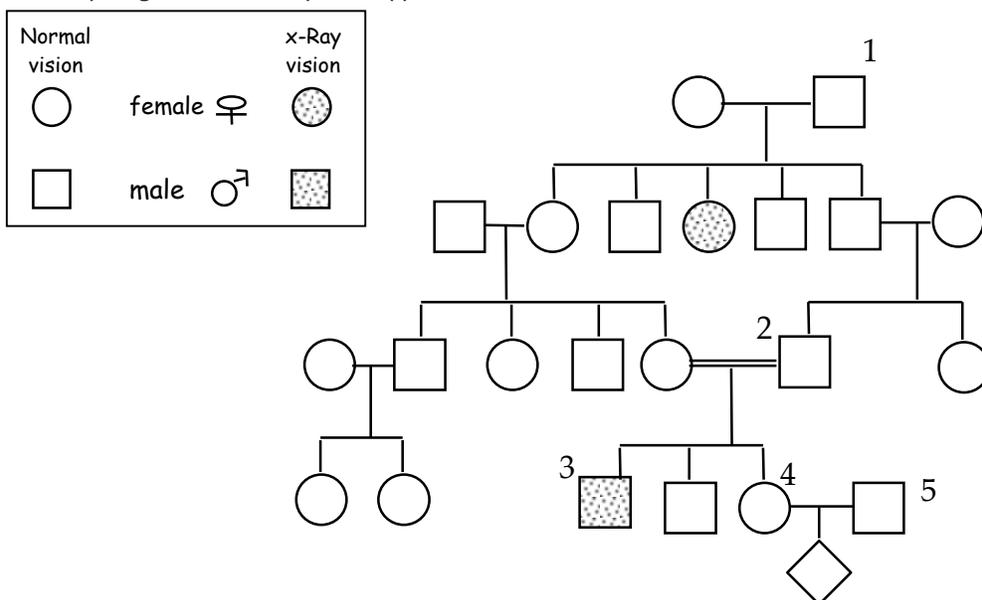
FRIDAY February 18, 2004

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.)

autosomal recessive

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?

Rr

c) What is the genotype of individual 3?

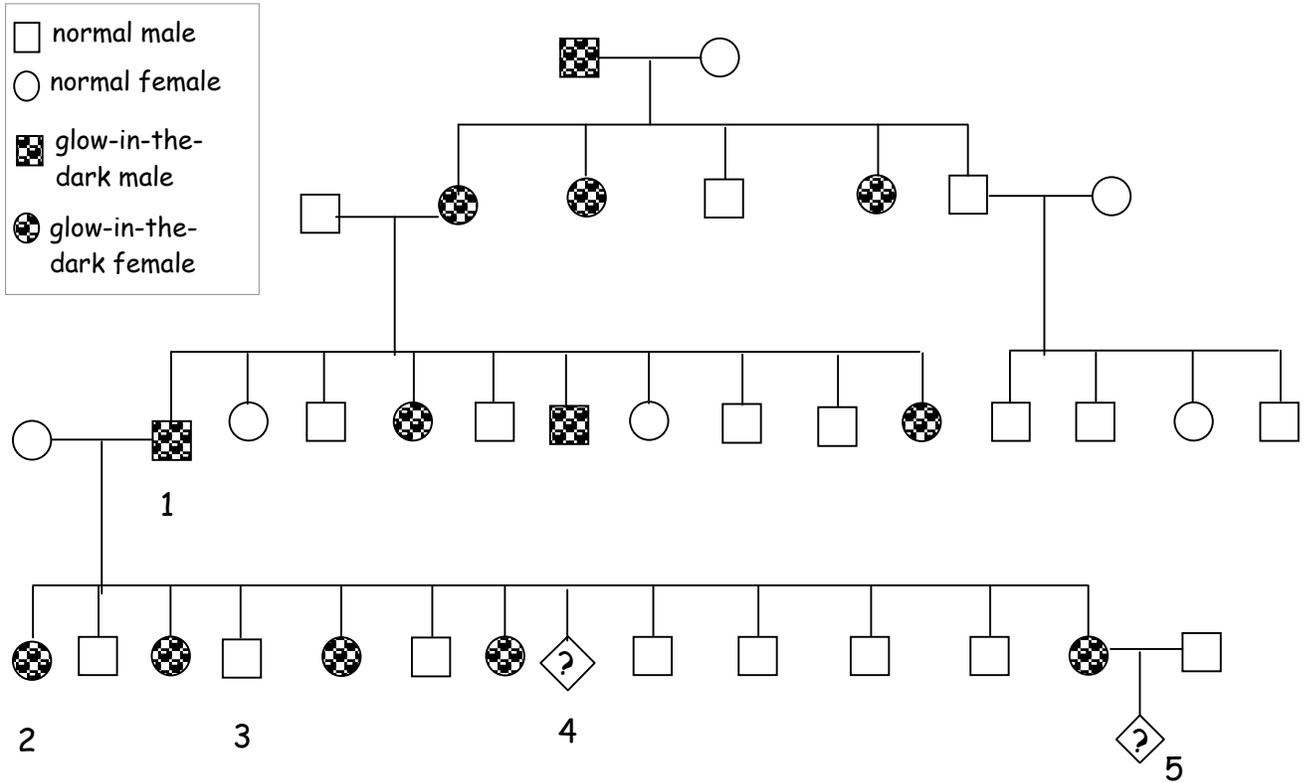
rr

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.

2/3 chance of being Rr vs RR, X 1/2 probability of giving allele --> producing heterozygote = 1/3

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? _____
 Individual #1? $X^R Y$ Individual #2? $X^R X^r$ Individual #3? $X^r Y$

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

If male, $P = 0$. If female, $P = 1$. (Or, if autosomal dominant, $P = 0.5$)

If male _____ If female _____

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

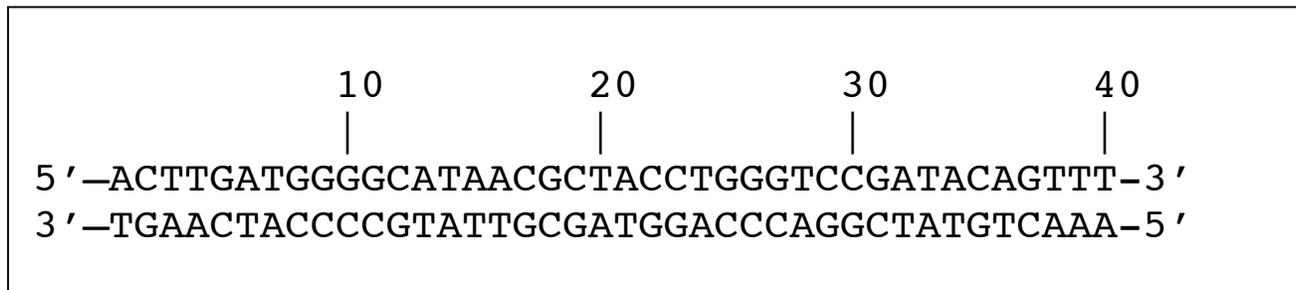
0.5 for both

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

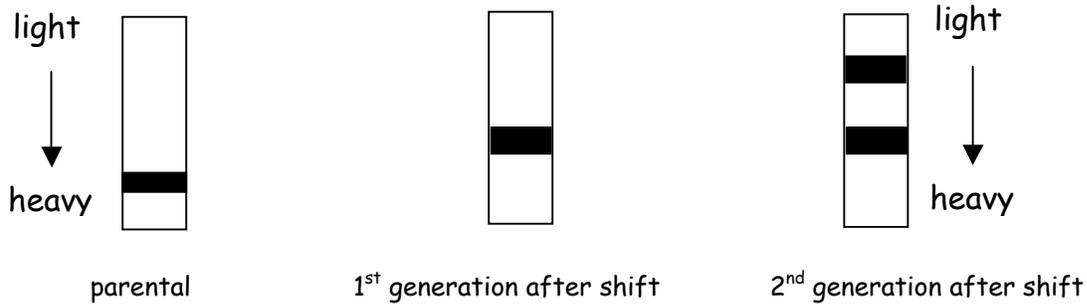
b) If the Martian DNA polymerase synthesizes DNA in the 5' to 3' direction, write the resulting DNA sequences and indicate the polarity (5' and 3') and the lengths (in nucleotides) of the daughter strand(s) on the figure below.



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.

No, there is only replication of part of one strand.

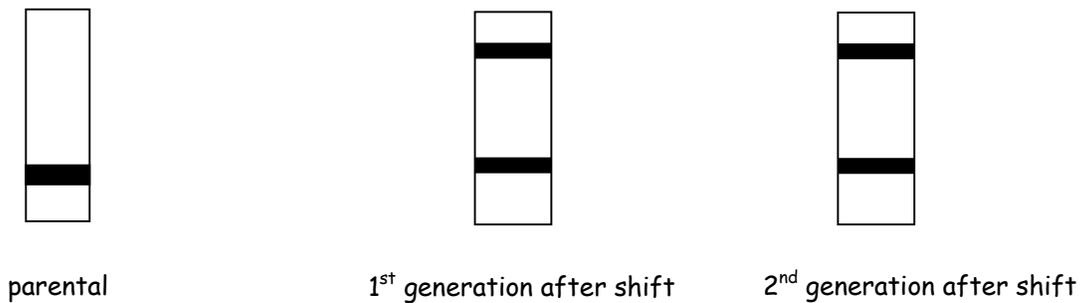
c) Meselson and Stahl demonstrated that *E. coli* replicates in a distinct manner. (See textbook, pgs 221-222.) This was shown by first growing *E. coli* in medium containing ^{15}N for the first few generations, shifting the culture to medium containing lighter ^{14}N and then examining the density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



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 F₁.

P:	BB - Black	bb - White
	F1: Bb - Black	

b) In order to test your hypothesis, you take 10 pairs of the offspring (F₁) from the above cross, and mate them to each other, to produce 100 new offspring (F₂). If your hypothesis is correct:

i) What fur colors will you see in the F₂ generation?

Black and white

ii) What are the corresponding genotypes?

BB - black Bb - black bb - white

iii) Roughly how many mice of each genotype and phenotype do you expect to see of the 100 F₂ progeny? Show your work.

**Ratio from hybrid cross will be BB:Bb:bb
1:2:1**

So, 25 BB 50 Bb 25 bb thus, 75 black 25 white

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 F₁ 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 F₂ mice with respect to eye color and coat color?

BB - green eyes, black fur Bb - green eyes, black fur bb - red eyes, white fur

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 F₂ mice? List their corresponding phenotypes.

BBGG - black coat, green eyes

BBGg - black coat, green eyes

BBgg - black coat, red eyes

BbGG - black coat, green eyes

BbGg - black coat, green eyes

Bbgg - black coat, red eyes

bbGG - white coat, green eyes

bbGg - white coat, green eyes

bbgg - white coat, red eyes

Question 5 (continuation of previous question)

When the two of you stop bickering and go and check out the 100 F₂ 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 *testcross*. That is to say that you cross F₁ females to the male of 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.

Linkage between the two genes

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.)

Recombinants/total progeny * 100 = map distance in cM

$$(4+5)/(4+5+45+46) = 9 \text{ cM}$$

Recombinants/Total progeny

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