NAME_____TA_____Section #_____

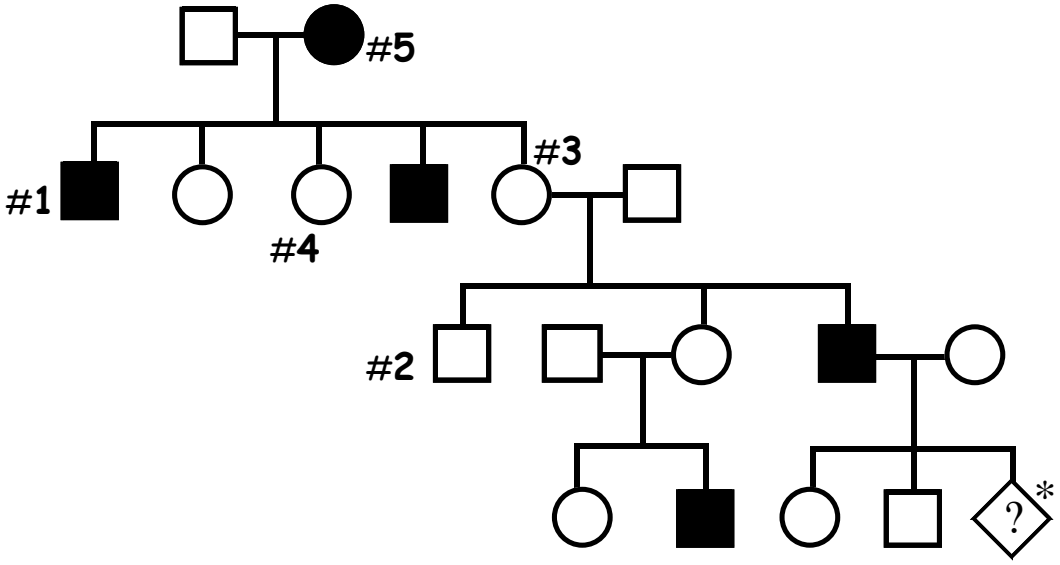
7.013 Problem Set 1 Solutions

FRIDAY February 13, 2004

Problem sets will NOT be accepted late.

Question 1

In the following pedigree, assume no outsiders marrying in carry a disease allele.



a) What is the mode of inheritance of this disease? Circle one.

Autosomal dominant	Autosomal recessive	X-linked dominant
Y-linked	mitochondrial inheritance	**X-linked recessive**

b) Explain your choice in a). (Give two lines of reasoning.)

all sons of affected mother are affected, but none of her daughters
many more males affected than females
disease never transmitted by father to his children

c) Write the genotypes of the following individuals.
(If more than one genotype is possible, write down **all** the possibilities.)

#1___X^dY___ #2__X^DY__ #3__X^DX^d__ #4_X^DX^d __ # 5_X^dX^d__

d) Name a disease that follows this pattern of inheritance.
(You may go to OMIM to answer this. → http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=OMIM)

hemophilia/ Duchenne's Muscular Dystrophy

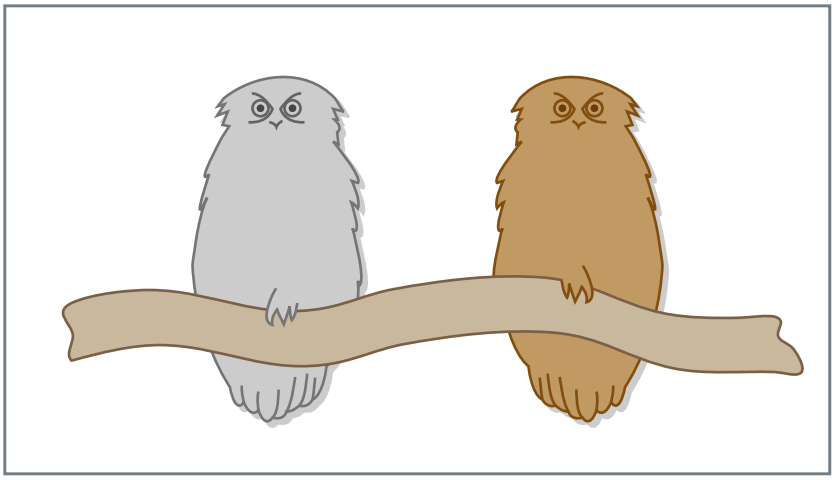
e) What is the probability that the asterisked individual will be affected with the disease
if male?_____ if female?_____

*0% chance * is affected*

Question 2

Harry wants to buy his friend's parents some owls for their anniversary, but he doesn't have a lot of money. He goes to the owl store anyways hoping to make an arrangement with the owner. Turns out that a disgruntled employee managed to erase all of the owner's computer files containing the genetic information of the extensive owl collection. If Harry can help the owner associate each phenotype with a genotype, he gets all the owls he wants.

a) Harry notices there are both gray and brown colored owls. If gray and brown hues are determined by a single Mendelian locus what are all the **genotypes** that could correspond to each of the **two** phenotypes if:



Figures by MIT OCW.

(Use **H** as your symbol for the dominant trait allele and **h** for the recessive trait allele.)

i) brown is dominant to gray?

i. HH, Hh = brown; hh = gray

ii) gray is dominant to brown?

ii. HH, Hh = gray; hh = brown

b) Harry sets up following matings, which always result in the same **ratios** of offspring indicated below.

i) Based on the results of **all** three crosses, and using the same symbols as on the previous page, what are the genotypes for each of the parents and offspring? Write clearly adjacent to each F_0 parent or F_1 class.

F_0 gray x gray

↓

F_1 all gray

F_0 brown x brown

↓

F_1 1 gray: 2 brown

F_0 gray x brown

↓

F_1 1 gray: 1 brown

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ii) Explain the ratios seen in the offspring for each of the crosses in i).

gray= hh; brown= Hh.

The first mating is between two homozygotes for the same allele, so all offspring will be the same.

The third mating shows a test cross where a homozygote for the recessive allele (hh) is mated to a heterozygote (Hh), and the offspring show the expected 1Hh:1 hh ratio.

The second mating is two heterozygotes mating (Hh x Hh), so the offspring will be 1HH:2Hh:1hh. Since the ratio we see is 2brown:1 gray, the HH class must be lethal.

Question 2 cont.

Figure removed due to copyright reasons.

In a different and **very cute** species of owl, Harry notices that members of this species emit two different noises which he names "loud" and "quiet", and that they have either smooth or rough eyelids. Harry sees a tank of very young owls, with no indication of who the parents were.

a) Assuming all of these young owls come from the same mating pair and given the following ratio of phenotypes that Harry tabulated below, what phenotype and genotype were associated with the **parents?** Use N and n to denote the alleles for noise, and E and e for eyelid textures.

17 loud and rough
5 loud and smooth
6 quiet and rough
2 quiet and smooth

This boils down to a 9:3:3:1 pattern, indicative of the parents both being heterozygotes for the two traits (NnEe), thus showing the dominant traits. The dominant traits will be the largest class of offspring. Therefore the parents were loud and rough.

NnEe

b) Draw a Punnett square to show the genotypes of the young owls discussed in a) and indicate which phenotypes correspond to these genotypes of the owls.

loud and rough
loud and smooth
quiet and rough
quiet and smooth

	NE	Ne	nE	ne
NE	**NNEE**	**NNEe**	**NnEE**	**NnEe**
Ne	**NNEe**	*NNee*	**NnEe**	*Nnee*
nE	**NnEE**	**NnEe**	nnEE	nnEe
ne	**NnEe**	*Nnee*	nnEe	nnee

c) If Harry mates a randomly chosen loud and rough eyelided owl to any quiet and smooth-eyelided owl, could he determine the genotype of the loud and rough owl by looking at the offspring?
Explain how.

These are the four possible outcomes of choosing a random loud and rough owl to mate to a quiet and smooth owl, each of which is different so you can determine the parent.

NNEE x nnee -> NnEe = all loud and rough
NNEe x nnee -> NnEe:Nnee = 1 loud and rough: 1 loud and smooth
NnEE x nnee -> NnEe:nnEe = 1 loud and rough: 1 quiet and rough
NnEe x nnee -> NnEe :Nnee,: nnEe: nnee = all four classes represented equally

d) Luckily, Harry finds some of these same cute owl species, whose genotypes for the alleles conferring flight ability (normal flight speed vs. wicked fast flight speed) and beak length (long vs. normal) are written on their cages.

i) Since he has all possible genotypes, what mating could Harry set up to determine if the two genes (loci) conferring flight ability and beak length are on the same chromosome?

Harry can set up a test cross. This is a mating between a heterozygote for both alleles and a homozygote for both of the recessives alleles.

ii) What ratio of offspring classes would Harry get if the loci are unlinked?

The offspring show the expected 1:1:1:1 ratio of phenotypes, then the alleles are unlinked and are on different chromosomes.

iii) How would this ratio change if the loci are tightly linked?

If the offspring do not show the expected 1:1:1:1 ratio of phenotypes, then the alleles are linked on the same chromosome. He would see a bias towards the parental phenotypes.

iv) How should he calculate the recombination frequency between the two loci?

The recombination frequency is the total number of recombinants divided by the total number of offspring.

v) What does this number represent with respect to the DNA?

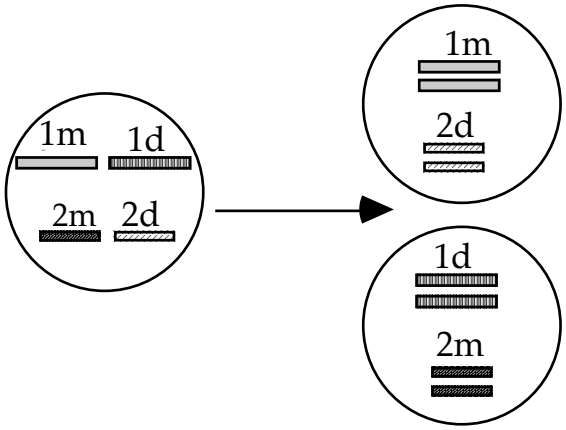
The recombination frequency is a measure of how close two alleles are to each other on a chromosome; the closer they are the less likely there will be a recombination event between them, thus a smaller recombination frequency. A recombination frequency of 0.01 =1% = 1 map unit = 1 cM.

e) What would be the genotype(s) of **your** ideal owl? Explain why.

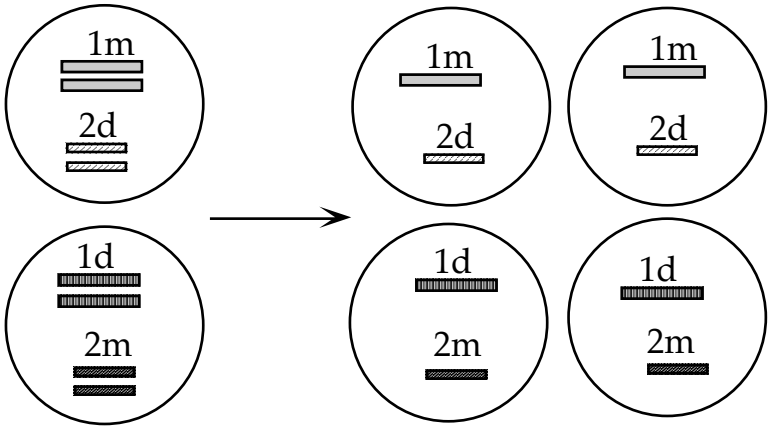
Question 3

The following diagrams show a diploid cell with 2 chromosomes, 1 and 2. The chromosome derived from the mother is denoted "m", and the chromosome derived from the father is denoted "d".

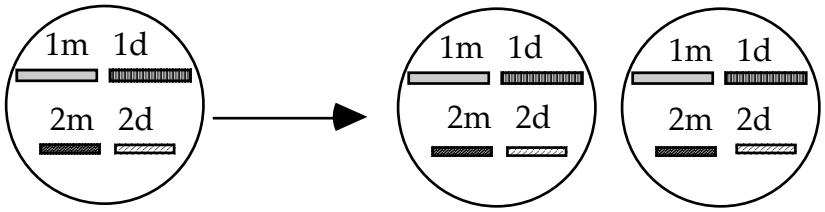
a) The picture below shows the end of mitosis/<u>meiosis I</u>/meosisII. (Circle one.)



b) The picture below shows the end of mitosis/meiosis I/<u>meosisII.</u> (Circle one.)



c) The picture below shows the end of <u>mitosis</u>/meiosis I/meosisII. (Circle one.)



d) In which stage of mitosis or meiosis does most of the recombination occur? Explain why.

Question 4

A woman with blood type O has a child with blood type O. She claims that a friend of hers is the child's father. In the ABO system, I^A and I^B are both dominant to I^O and are codominant to each other. ABO genotypes are summarized below and described on page 187 of the 6th edition of Purves.

I^AI^A	and I^AI^O	A
I^BI^B	and I^BI^O	B
I^AI^B		AB
I^OI^O		O

a) Her friend's blood type is A. Can he be excluded as the father on this evidence alone?
NO.
The mother is I^OI^O *and the child is* I^OI^O. *The man (with type A blood) could be* I^AI^A *or* $I^A\ I^O$. *If he is* $I^A\ I^O$, *he could contribute a* I^O *allele, so he cannot be ruled out as the child's father.*

b) Does the fact that the accused man's mother has type A and his father has type AB exclude him from being the parent?
NO.
His mother (type A) could be I^AI^A *or* $I^A\ I^O$. *and his father (type AB) must be* I^AI^B. *The man could have type A blood (and the* $I^A\ I^O$ *genotype) if his mother contributed her* I^O *allele and his father contributed his* I^A *allele. Therefore, this information cannot rule exclude the man as the child's father.*

c) Does the additional information that his mother's parents are both AB permit him to be excluded?

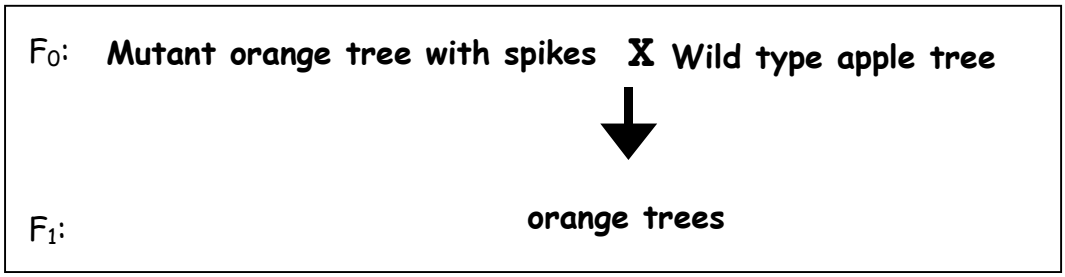
YES.

If his mother's parents are both type AB (I^AI^B*), then his mother must be* I^AI^A *and she could not contribute an i allele to her son. Therefore, the man must also be* I^AI^A. *This information would exclude him as the child's father. (Provided these are his real parents.)*

Question 5

Harry got his genetic savvy studying apple tree genetics.

He had a pure-breeding mutant strain of apple trees that has two unusual characteristics; the mutant tree produces oranges instead of apples and there are huge spikes growing out of the branches. Harry crossed the mutant with a pure-breeding wild-type apple tree. The F_1 progeny produce oranges, but have no spikes.



a) For each pair, circle the dominant phenotype.

Apples **Oranges** Spikes **No spikes**

b) Harry performed a backcross of an F_1 individual with an F_0 individual from the mutant strain. If there are **32** progeny trees from this cross how many trees have each of the following phenotypes?

Apples, spikes _____0_____

Apples, no spikes _____0_____

Oranges, spikes _____16____

Oranges, no spikes _____16___

Harry performed a test cross of an F_1 individual (from the very first cross) with a tree exhibiting both of the phenotypes that you have identified as recessive. He got progeny with the following characteristics.

Phenotype	**# of individuals in F_2 generation**
Apples, spikes	103
Apples, no spikes	903
Oranges, spikes	897
Oranges, no spikes	97

c) What is the recombination frequency between the "*orange*" and the "*spike*" genes? Show your work.

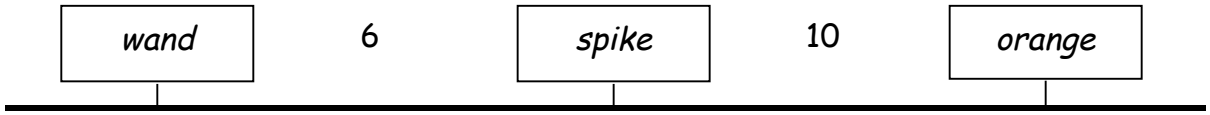
97+103/ 103+97+903+897= 200/2000--> 10%

_____10%_____

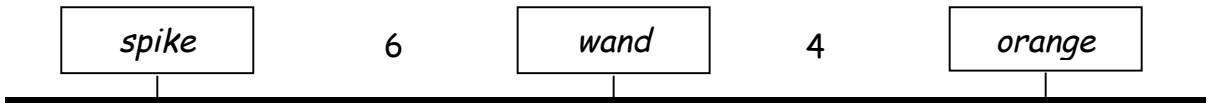
Harry had previously identified a mutant apple tree whose branches are magical, and can be used to make magic wands. The gene that produces this phenotype (the "*wand*" gene) was previously determined to be 6 map units away from the "*spike*" gene on one chromosome.

d) Based on the above data, there are two possible arrangements for the "*orange*", "*spike*", and "*wand*" genes on the chromosome. Draw them below naming the genes in the boxes and indicating between them the distances in map units.

Arrangement 1:



Arrangement 2:



e) What experiment could Harry perform to distinguish between these two possibilities?

A cross to determine the distance between orange and wand. A tree heterozygous at both the wand and orange loci crossed with the double recessive homozygote will lead to information to determine the correct orientation.