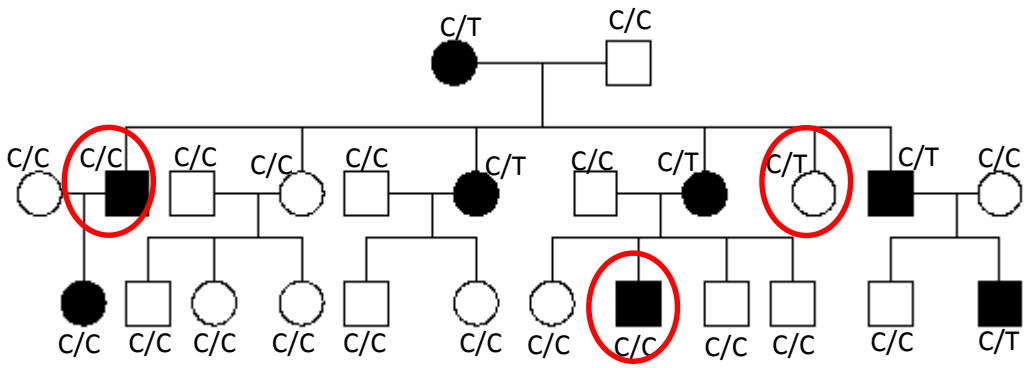
BB2920-C16 Problem Set 4

Due in class on Monday 2/15/16

Problem 1 (20 points)

Below is the pedigree that depicts a rare but mild genetic disease. Adjacent to each individual is the haplotype for a common polymorphism, a C/T SNP on Chr 22.



a) (5 points) What is the most likely inheritance pattern for this disease? Give two specific facts from the pedigree that support your conclusion.

Autosomal dominant (1 point) because:

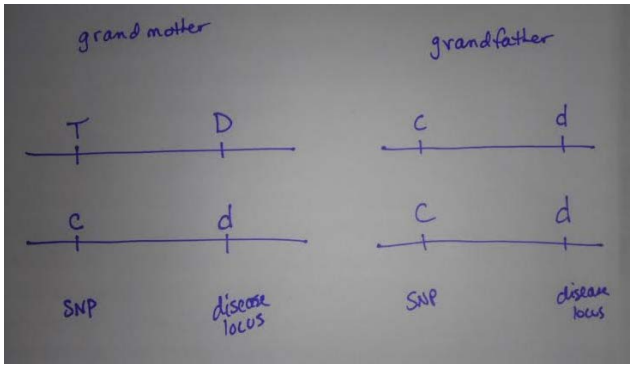
1) affected parents have ~50% affected offspring (2 points)

2) males and females are equally affected. (2 points)

b) (2 points) Is there evidence of linkage between the SNP and the disease allele? Briefly explain your response.

Yes – individuals that have the disease also tend to have the T version of the SNP, whereas very few unaffected individuals have the T SNP. (2 points)

c) (4 points) If there is evidence of linkage, sketch the arrangement of the alleles on chromosome 22 for each of the two grandparents. Use the allele designations D and d for the disease alleles, and C or T for the haplotype.



Recall that this is dominant so the disease allele is D, not d! 4 points per correct chromosome.

Make sure the correct alleles are on the right chromosomes together!

d) (3 points) Circle the individuals on the pedigree that are recombinants. (see above) 1 point each, -1 for any wrong circles (so, if they just circle everyone on the pedigree that is no credit even if the correct recombinants are in there)

Note that the first person in generation 3 is NOT recombinant! The parent was recombinant, but the offspring has the same chromosome as their parent so this individual is NOT recombinant.

e) (4 points) If there is evidence of linkage, use the information provided in the pedigree to estimate the distance between the SNP and the disease allele in map units.

There are 3 recombinant individuals out of a total of 18 offspring we can consider (we can only consider individuals for whom their parentage in known, so people that marry into this family like the first individual of generation 2 are not considered as offspring). 3 of these 18 are recombinants. So using our simple equation to calculate recombination frequency: 3/18 * 100% = 16.67% recombination, which is equal to 16.67 m.u. (calculation should be present but no explanation is required. no partial credit.)

f) (2 points) The distance between these two genes calculated in part e is likely to be an underestimate. Why?

If recombination happens between an individual that is d/d and has the C SNP on both chromosomes, we would not be able to detect it. Probably some recombination has occurred that we don't see, so the two genes are probably farther apart than this estimate indicates.

Problem 2 (15 points)

The following cross is performed with two pure-breeding *Drosophila* individuals: a female with normal wings and red eyes (vg+/vg+ · cn+/cn+) and male with vestigial wings and brown eyes (vg/vg · cn/cn). The F1 progeny are testcrossed. What percentage of the offspring from the testcross will be vg/vg · cn/cn if the two genes are:

a) unlinked?

b) so tightly linked that crossing over does not occur?

c) linked and 17 m.u. apart?

Show your work and provide a very brief explanation for your response.

a) if the genes are unlinked, all four progeny classes including vg/vg · cn/cn would be equal, so 25%

b) if the genes are completely linked, the only possible offspring will be the parental types from the F1 testcross (vg+/vg+ · cn+/cn+ and vg/vg · cn/cn) , so 50%

c) If the two genes are linked by 17 m.u., the recombination frequency (RF) is 17%, and the parental types would be 83%. vg+/vg+ · cn+/cn+ is a parental type, so it will make up half of the total parental types, so 41.5 of offspring%.

5 points for each section, no partial credit within each section.

Problem 3: (16 points) In the following cross, the genes are inherited independently except for *C* and *D*, which are tightly linked and show zero recombination: *A/A ; b/b ; c/c ; D/D ; e/e ; F/F* x *a/a ; B/B ; C/C ; d/d ; E/E ; f/f*. These two parents are crossed, and the F1 progeny are self-crossed. What proportion of individuals in the F2 generation will be:

a) pure breeding?

b) homozygous recessive for all loci?

c) *A/a*;*B/B*;*c/c*;*D/D*;*E/e*;*f/f*?

d) genotypically identical to either original parent?

(4 points per response)

Answer: The F_1 is of the following constitution: *A*/*a* ; *b*/*B* ; *c D*/*C d* ; *e*/*E* ; *F*/*f*. The C and D loci behave like one locus.

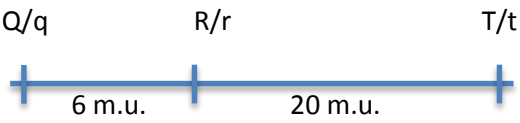
a) ½ × ½ × ½ × ½ × ½ = 1/32

b) zero because of the trans arrangement of *c* and *d*

c) ½ × ¼ × ¼ × ½ × ¼ = 1/256

d) (¼ × ¼ × ¼ × ¼ × ¼) + (¼ × ¼ × ¼ × ¼ × ¼) = 2/1024 = 1/512

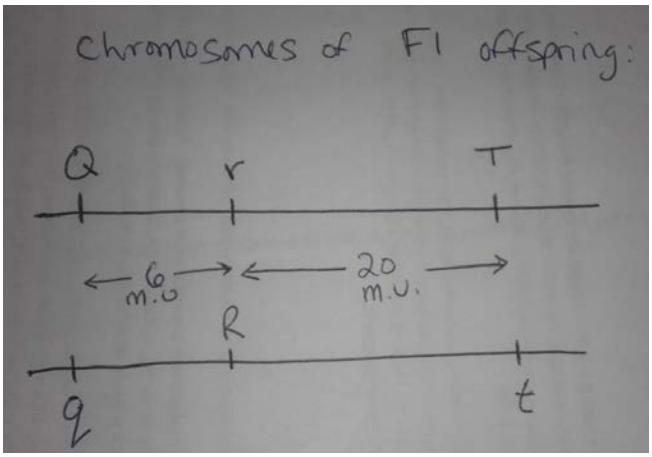
Problem 4 (16 points) In corn plants, the cross Q/Q · r/r · T/T x q/q · R/R · t/t is made. The three loci are linked as follows:



a) (2 points) What is the genotype of the F1 progeny?

Heterozygous at all loci (Qq Rr Tt) - 2 points for this genotype

b) (6 points) Draw the two chromosomes contained by the F1 progeny.



Graders: NOTE! The alleles are arranged in trans – the R allele is NOT on the same chromosome as the Q and T alleles. If they drew all the dominants on the same chromosome that is wrong! (watch the allele distribution!, 6 points for this part, award only 2 points if they drew the alleles in the cis conformation, no other responses should receive credit)

b) (8 points) A testcross of the F1 progeny is now performed. What percentage of the testcross progeny will be of the genotype qq rr tt? (HINT! You will need to figure out individual recombination frequencies and then apply the product rule!). Explain your reasoning and show your work.

In order to get this genotype, there must be two crossovers. (2 points for explaining that a DCO/two crossover events are required to obtain this genotype)

RF for Q and R is 6% or 0.06. RF for R and T is 20% or 0.20. To get the number of double crossover individuals, apply the product rule: 0.06 x 0.20 = 0.012 or 1.2%. (4 points for this calculation)

However, this 1.2% encompasses ALL double crossover individuals (qq rr tt AND QQ RR TT). So the proportion of qq rr tt is 1.2% / 2 = 0.6% (2 points for recognizing the need to divide by 2)

Some students may have applied the principle of taking half of the RF as one specific recombinant progeny before applying the product rule to get double recombinants (eg: 6% recomb. is 3% qq rr, and 20% recomb is 10% rr tt, so 0.03 x 0.10 = or 0.3%.) This response will also receive full credit.

The reason this isn't quite right is because when you take half of the recombinants before you apply the product rule (eg, when you take 3% instead of 6%) you end up multiplying the "1/2 factor" and end up with only 1/4 - which is why this response (0.3%) is 1/4 of 1.2% total double recombinants as calculated above. Don't worry if this doesn't make sense to you, just trust me. Anyhow, either 0.3% or 0.6% will receive full credit.

Problem 5 (12 points) Two new mutant lines of a flowering plant have been obtained; one breeds true for blue flower color and the other breeds true for red flower color (wild-type flower color is purple). Consider the following crosses.

1. blue × purple → F_1 all purple → F_2 75% purple; 25% blue

2. red × purple → F_1 all purple → F_2 75% purple; 25% red

3. red × blue → F_1 all purple

The red pigment is a precursor of the purple pigment, the blue pigment is a precursor of the red pigment, and a colorless compound is the precursor of the blue pigment in a linear biosynthetic pathway controlling flower color.

blue → red → purple

BB RR

a) Write the genotypes of each of the original parental plants in the three crosses above. (6 points)

1. bbRR x BBRR

2. BBrr x BBRR

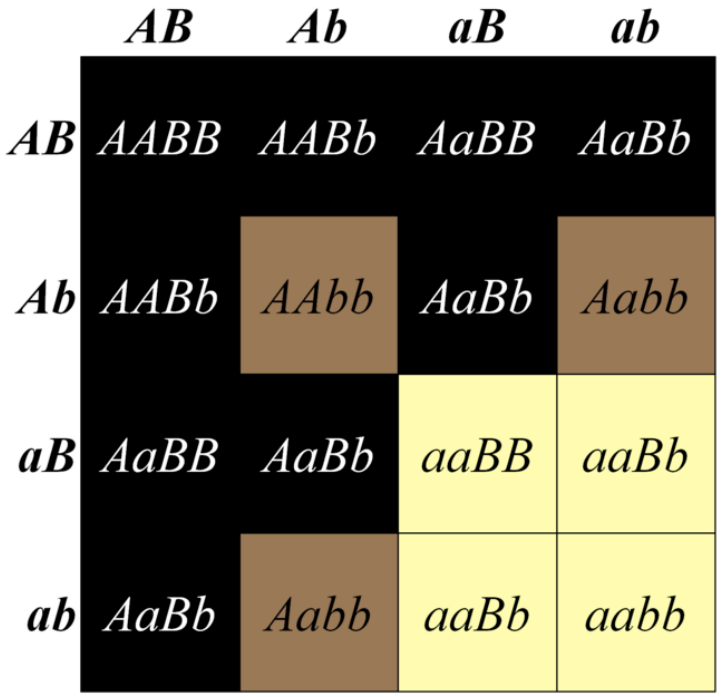
3. BBrr x bbRR

one point per genotype

b) What phenotypic ratios do you expect in the F_2 of cross 3? Show your work.(6 points)

9 purple : 4 blue : 3 red (2 points)

An example of a 16-block punnett square to demonstrate (below) is an example of the 9:4:3 ratio (in our case the black squares would be purple, yellow squares would be blue, and brown squares would be red) (4 points for either drawing out the punnett square or at least writing out the possible genotypes and indicating the color of each offspring, either way it ok.)



	AB	Ab	aB	ab
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

Problem 6: (10 points) *Drosophila* eyes are normally red. Several purple-eyed strains have been isolated as spontaneous mutants, and the purple phenotype has been shown to be inherited as a Mendelian autosomal recessive in each case. To investigate allelism between these different purple mutations, two purple-eyed pure strains were crossed.

a) If the purple mutations are in different genes (i.e., they are *not* allelic), the phenotypic ratios in the F_1 are expected to be:

A) 100% red. (2 points)

B) 75% red : 25% purple.

C) 50% red : 50% purple.

D) 25% red : 75% purple.

E) 100% purple.

Provide a brief justification for your response: these are mutations in different genes, so the resulting offspring are heterozygous at each gene locus and are therefore phenotypically wildtype (red). These mutations complement each other. (3 points)

b) If the purple mutations are in the same gene (i.e., they *are* allelic), the phenotypic ratios in the F_1 are expected to be:

A) 100% red.

B) 75% red : 25% purple.

C) 50% red : 50% purple.

D) 25% red : 75% purple.

E) 100% purple. (2 points)

Provide a brief justification for your response: these mutations do NOT complement because they are in the same gene, so the offspring have two mutant copies of the gene and are therefore phenotypically mutant (purple) (3 points)

Problem 7 (11 points) In a certain breed of dog, the alleles *B* and *b* determine black and brown coats, respectively. However, the allele *Q* of an unlinked gene is epistatic to the *B* and *b* color alleles, resulting in a gray coat (*q* has no effect on color).

a) What is the phenotype of a *B/b; Q/q* animal? Very briefly explain.

gray, because any animal with a dominant Q allele will be gray (Q is epistatic to B) (7 points, 4 points for the color and 3 points for the explanation)

b) If two animals each of genotype *B/b; Q/q* are crossed, what phenotypic ratio is expected in the progeny?

12 gray, 3 black, 1 brown. (4 points, demonstration of the genotypes/punnett square is not required, but many students will likely need to write out the punnett square in order to visualize this.)