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2006 7.012 Problem Set 2

Due before 5 PM on FRIDAY, September 29, 2006.
Turn answers in to the box outside of 68-120.
PLEASE WRITE YOUR ANSWERS ON THIS PRINTOUT.

1. You are doing a genetics experiment with the fruitfly *Drosophila melanogaster*. In the "P" generation, you cross two true-breeding flies. The two flies are a large-winged hairless female and a puny-winged hairy male. All of the flies in the F1 generation are large-winged and hairy.

Indicate the alleles associated with dominant phenotypes by a capital letter and alleles associated with recessive phenotypes by a lowercase letter. Assume the two traits you are following are autosomal. Indicate the hair alleles by the letters "H" and "h" and indicate the wing alleles as "G" and "g."

(a) The genotypes of the flies in the P generation are:

________________________ females and ________________________ males.

The genotypes of the flies in the F1 generation are:

________________________ females and ________________________ males.

You now take an F1 generation female and cross her to a true-breeding puny-winged hairless male.
This male's genotype is: ________________________ .

(b) You count 1600 offspring in the F2 generation. If the wing and the hair traits were unlinked, you would expect to count:

_________# of large-winged hairy flies (of the genotype _________________________)

_________# of large-winged hairless flies (of the genotype _______________________)

_________# of puny-winged hairless flies (of the genotype _______________________)

_________# of puny-winged hairy flies (of the genotype _________________________)

(c) Instead, when you count the F2 generation, you really get:
85 large-winged hairy flies
712 large-winged hairless flies
75 puny-winged hairless flies
728 puny-winged hairy flies
What is the genetic distance between the hair and wing genes?

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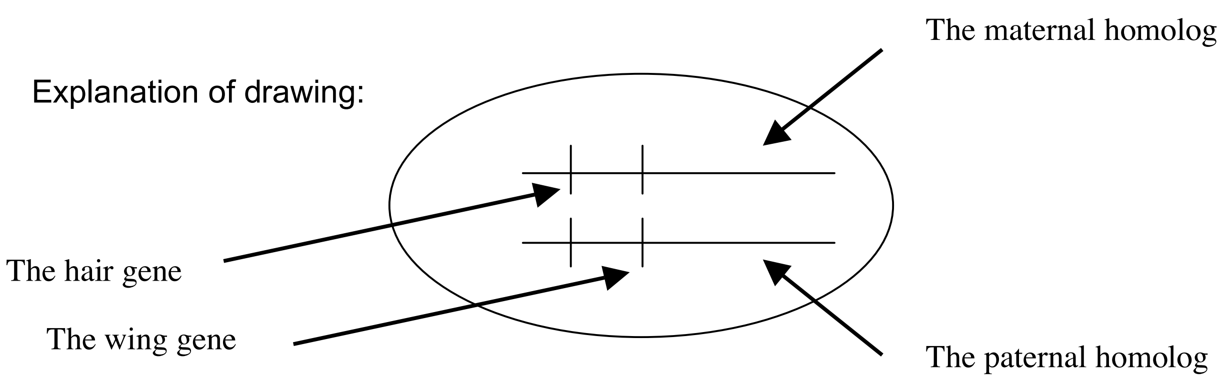
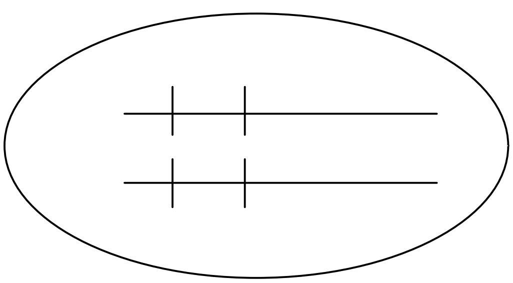
(d) A series of fruit fly matings shows that the recombination frequency between the gene for wing size and the gene for antenna length is 5% (i.e. the genetic distance between them is 5 centimorgans). List all possible recombination frequencies between the gene for amount of hair and the gene for antenna length.

(e) Draw out the arrangement of the hair and wing genes in the nucleus of a randomly selected eye cell in the following flies (which are the same flies that were described above). Draw the genotype inside the circles below, which indicate a nucleus of an eye cell. The long lines represent the pair of homologous chromosomes that have the genes for the hair and wing traits on them. The tick marks indicate the position of the two genes. **Write in a letter next to each tick mark in each cell** to indicate which alleles exist at each of the two genes on each of the two homologs.

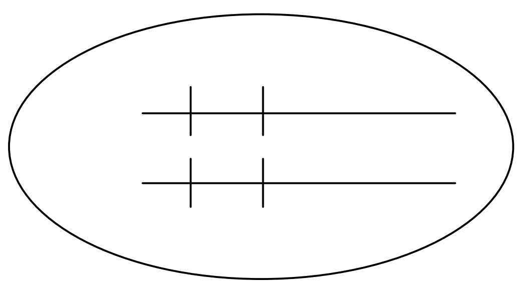
Explanation of drawing:



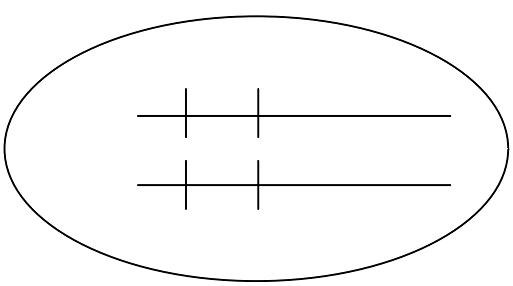
P generation female:



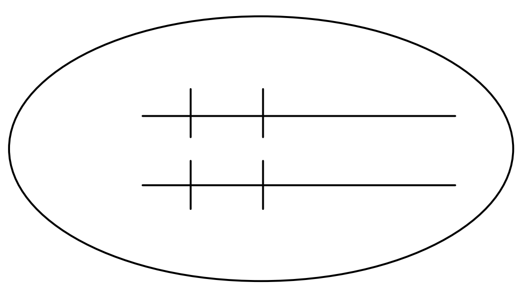
P generation male:



F1 generation female:



puny-winged hairless male (who was crossed to the F1 female):



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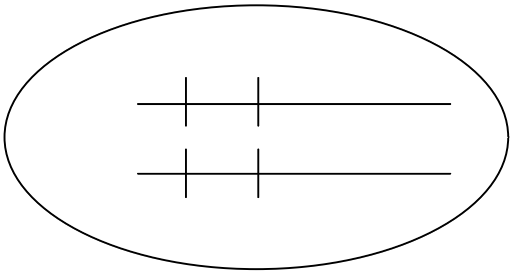
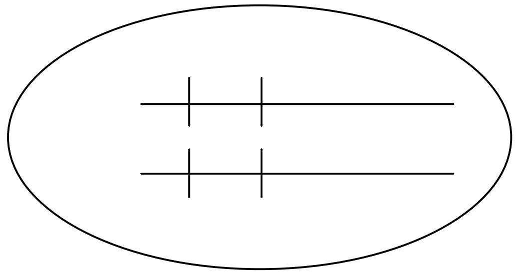
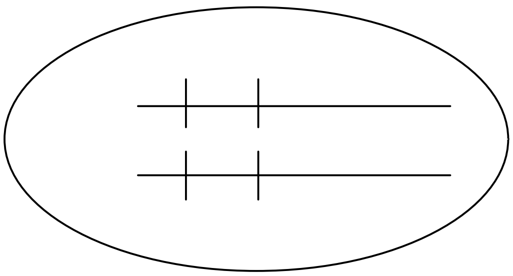
The four possible F2 generation flies created by the cross of the F1 female to the puny hairless male:

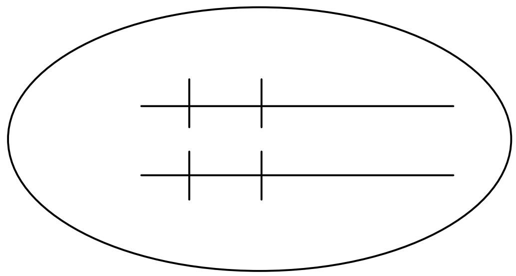
-- the two possible non-recombinants:





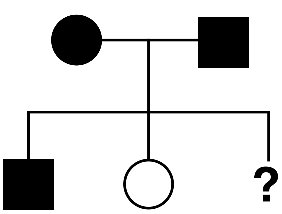
-- the two possible recombinants:



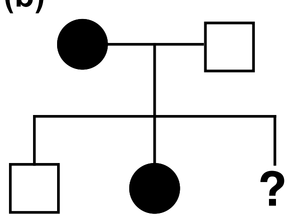


2. Each of the families below exhibits a different very rare genetic disorder where individuals expressing the disorder are shown by solid symbols. Give all possible modes of inheritance that are consistent with each pedigree (your choices are: autosomal recessive, X-linked recessive, X-linked dominant, or autosomal dominant).
Also calculate the probability that the next child indicated by a (**?**) will be affected given each possible mode of inheritance. In the case of X-linked inheritance, calculate separate probabilities for sons and daughters.

(a)



(b)



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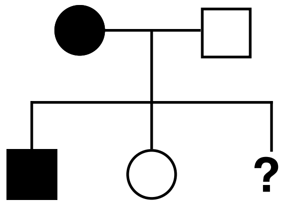
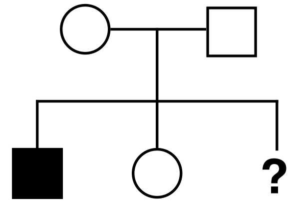
(c)

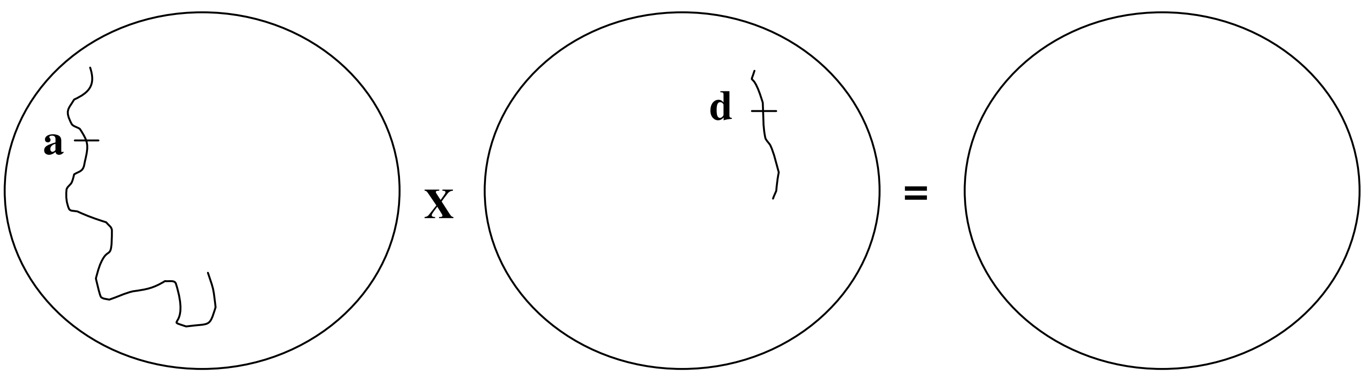


(d)

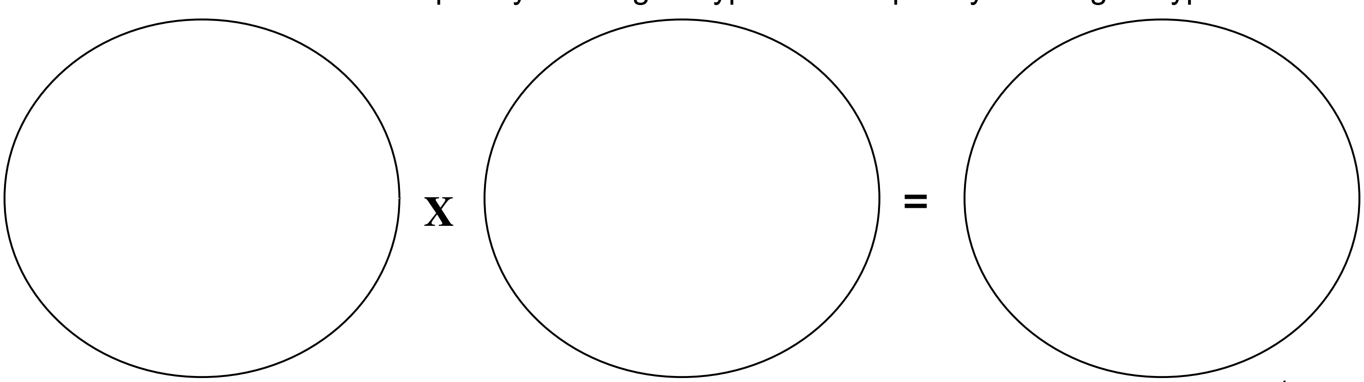


3. You are studying a type of yeast that has two different chromosomes in its genome. You have isolated three mutations, “a,” “b” and “d,” each of which causes the same phenotype. When you mate a strain containing any one of these three mutations to wild-type, the resulting diploid exhibits the wild-type phenotype. You are in the process of doing complementation tests with these mutants. You discover that “a” and “d” do complement each other, but “a” and “b” do not. The corresponding wild-type alleles are “A,” “B” and “D.” **Draw in the correct alleles** that exist at each of these loci (A, B, and D) in each of the six yeast cells drawn below. Make sure to put the alleles in their correct locations, as determined by those already drawn in for you. Also make sure to **draw in the chromosomes** to any cell whose chromosome(s) is/are missing.

First cross: You mate haploid yeast of genotype “a” to haploid yeast of genotype “d.”



Second cross: You mate haploid yeast of genotype “a” to haploid yeast of genotype “b.”



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4. Shown below is a hypothetical scheme for the formation of eye pigment in *Drosophila*.

$$\textbf{Blue pigment} \xrightarrow{\textbf{Bl}} \textbf{Purple pigment} \xrightarrow{\textbf{Pr}} \textbf{Red pigment}$$

The enzyme encoded by the **Pr** gene converts a purple pigment into the normal red pigment in the eye. The **pr**$^{-}$ allele causes the recessive phenotype of purple eyes. The enzyme encoded by **Bl** gene converts a blue pigment into the purple pigment. The **bl**$^{-}$ allele causes the recessive phenotype of blue eyes. Both the **Pr** and **Bl** genes are on the X chromosome. A male from a true-breeding blue-eyed strain is crossed to a female from a true-breeding purple-eyed strain.

(a) All of the F_1 female progeny from this cross have normal eyes. What colored eyes should the F_1 male progeny have?

(b) An F_1 female fly (with normal eyes) is crossed to a wild-type male, and a large number of male progeny from this cross are examined. Among the male progeny, there are flies with normal red eyes, flies with purple eyes, and flies with blue eyes. You notice that significantly more male progeny have blue eyes than have purple eyes. In one sentence or less, state why this should be the case.

(c) Given that the **Pr** and **Bl** genes are 20 cM apart on the X chromosome (i.e. the recombination frequency between them is 20%), determine the number out of 100 <u>male</u> progeny from the cross in part (**b**) that should have purple eyes, blue eyes, or normal red eyes.

<u>Number</u>

Purple-eyed males:

Blue-eyed males:

Red-eyed males:

Total = 100

5. In many of the classic experiments we discussed in lecture, scientists use different radioisotopes to label different components of the cell. Be as specific as possible in your answers below regarding these radioisotopes.

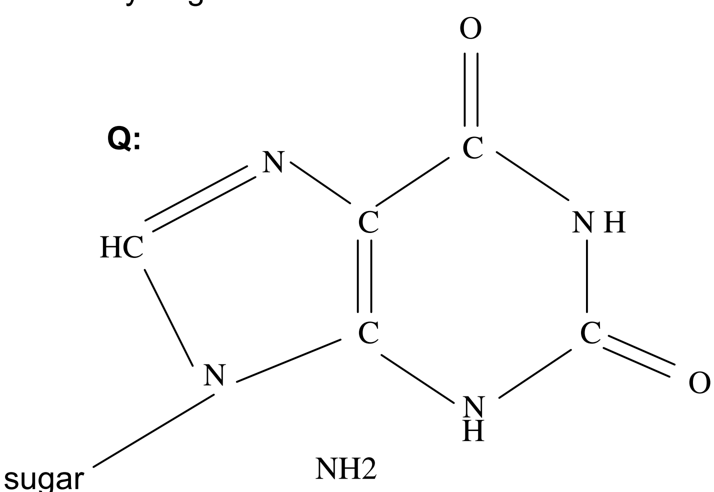
(a) Which specific part of DNA is radioactively labeled by N^{15}?

(b) Which specific part of protein is radioactively labeled by S^{35}?

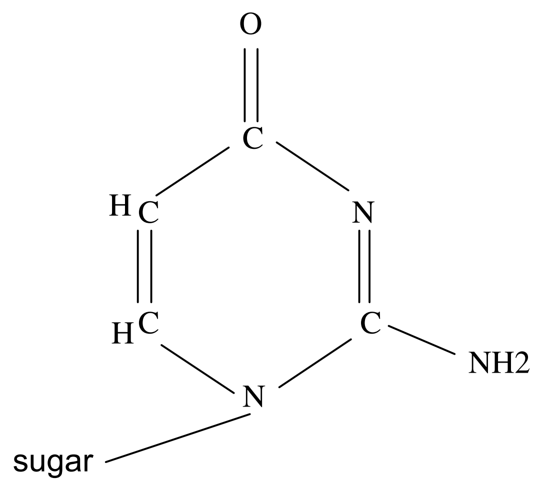
(c) Which specific part of DNA is radioactively labeled by P^{32}?

6. Imagine an organism that uses the four following nitrogenous bases, drawn below. Other than the identity of the bases, assume that every other aspect of the structure and function of this organism's DNA is the same as the DNA of organisms that use A, G, C, and T. Just as with the usual A, G, C, and T, there are two exclusive pairs of bases that hydrogen bond with each other.

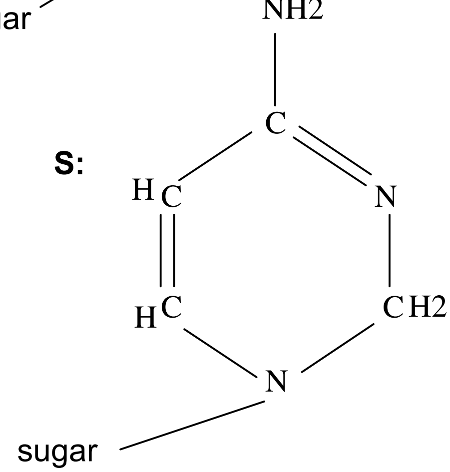
Q:



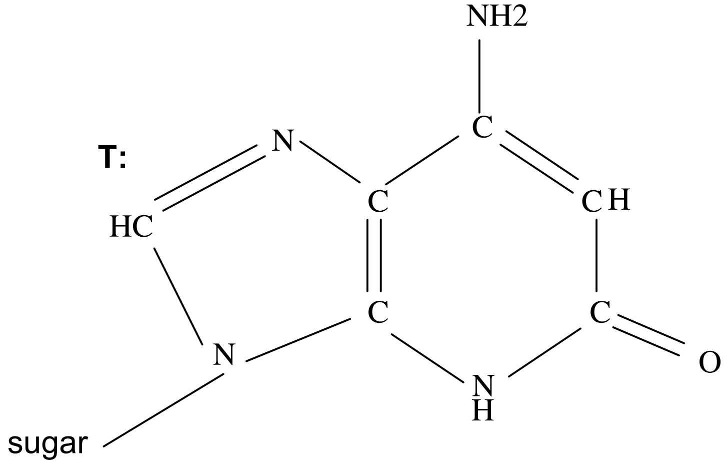
R:



S:



T:



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(a) Which base do you think pairs with each base below? Circle one base for each.

Q base pairs with…? (circle one)	Q	R	S	T
R base pairs with…? (circle one)	Q	R	S	T
S base pairs with…? (circle one)	Q	R	S	T
T base pairs with…? (circle one)	Q	R	S	T

(b) Draw one pair of bases, aligning them as they would in a double stranded DNA molecule, and showing the hydrogen bonds that could occur between them. (You do not have to draw the entire nucleotides; you only have to draw the nitrogenous bases.) Draw each hydrogen bond as a series of short dashes: ················

(c) Draw the other pair of bases, aligning them as they would in a double stranded DNA molecule, and showing the hydrogen bonds that could occur between them. Draw the hydrogen bonds as a series of short dashes.