

7.013 Problem Set 2- 2013

Question 1

You are working with the following parental flies (P1-P4).

P1: Light body color and normal wings

P2: Light body color and wingless

P3: Dark body color and wingless

P4: Light body color and normal wings

You set up three mating experiments using these flies and obtain the following results:

Experiment	Number of flies with the following phenotype			
	Light body color and normal wings	Light body color and wingless	Dark body color and normal wings	Dark body color and wingless
# 1: P1 with P2	60	60	20	20
# 2: P1 with P3	40	40	40	40
# 3: P3 with P4	160	0	0	0

a) Circle the **dominant phenotypes** from the choices below.

Light

Wingless

Normal wings

Dark

b) Give the likely genotypes with respect to body color and wing type for the following flies. Note: Please indicate the alleles associated with dominant phenotypes by uppercase letters and alleles associated with recessive phenotypes by lowercase letters. Indicate the alleles for the body color as "A or a" and the alleles for wing type as "B or b".

Genotype of P1 Fly:

Genotype of P2 Fly:

Genotype of P3 Fly:

Genotype of P4 Fly:

c) Which parental fly or flies, P1-P4...

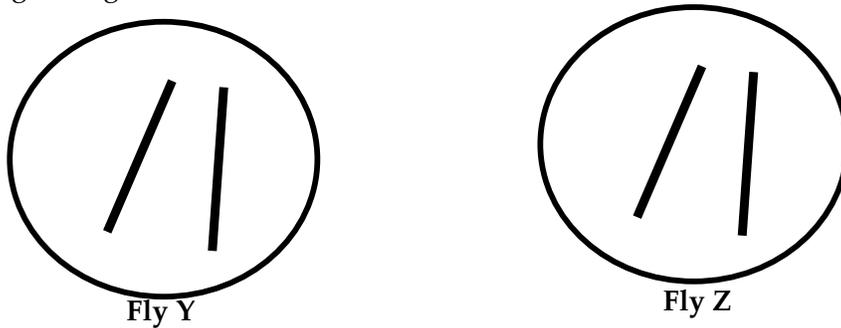
- i. Is homozygous at only **one** locus?
- ii. Is homozygous at **both** loci?

d) If you were to do a test cross in order to identify the genotype of a fly that showed the dominant phenotypes for both these traits, which of these flies (P1-P4) would you mate your test fly with?

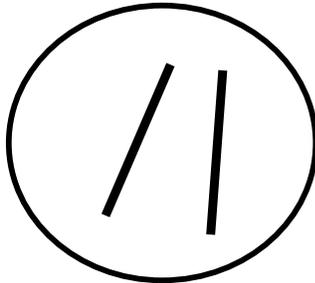
Explain why you selected this option.

Question 2

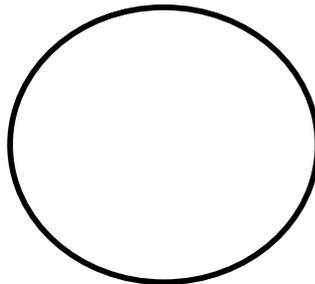
a) Below is a schematic of diploid nuclei **prior to DNA replication** from **fly Y with genotype AAbb**, and from **fly Z with genotype aaBB**. On the diagram below, label the chromosomes with the appropriate alleles of the genes that regulate body color (A or a) and wing type (B or b) assuming that the genes regulating these two traits are located on the same chromosome.



b) Below is a schematic of diploid nucleus **prior to DNA replication** from a fly that is the progeny of **fly Y** and **fly Z** above. Label the chromosomes with the appropriate alleles of the gene regulating body color and wing type.

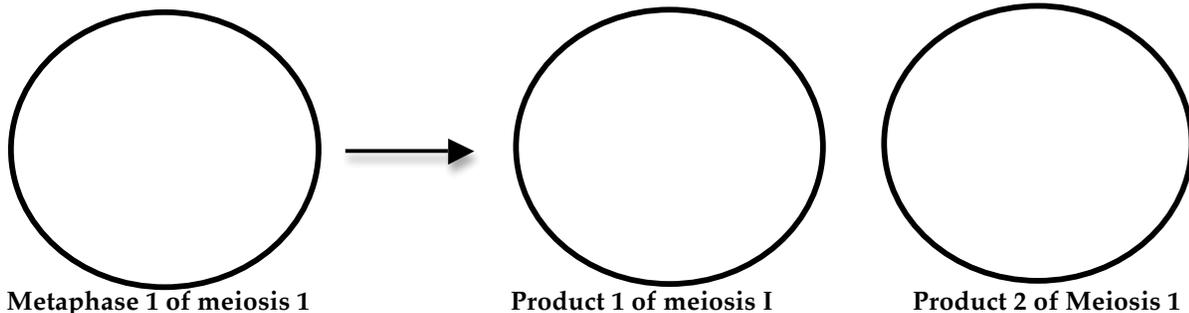


c) Now consider the diploid nucleus drawn in part (b) during **mitosis**. Draw and align the chromosomes as they would appear during metaphase of **mitosis**. Include the A, a, B, and b alleles on the drawing.



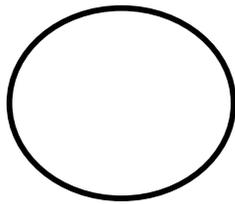
d) Now consider the diploid nucleus drawn in (b) above during **meiosis**.

- i. On the diagram below, draw and align the chromosomes as they would appear in **metaphase I of meiosis I**. Include the A, a, B, and b alleles in the schematic.
- ii. Given your drawing in part (i), draw the chromosomes in each of the two products resulting from meiosis I. Include the A, a, B, and b alleles in the schematic. *Note: For these diagrams, assume no recombination.*

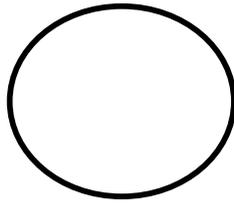


Question 2, continued

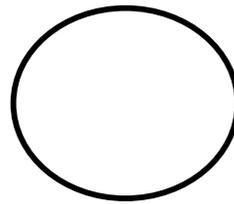
- iii. Draw the chromosomes in the nuclei of the four gametes that will be produced during **meiosis II**. Include the A, a, B, and b alleles in the drawing.



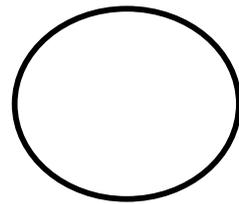
Gamete 1



Gamete 2



Gamete 3



Gamete 4

- iv. Give **all** the possible genotypes of the gametes that would be produced **if non-disjunction occurred in Product I of Meiosis I** that you have drawn in Part d (ii) on Page 2.

e) Now review Experiment #2 from Question 1 that is once again shown below for your convenience.

	Number of flies with following phenotype			
Experiment	Light body color and normal wings	Light body color and wingless	Dark body color and normal wings	Dark body color and wingless
# 2: P1 with P3	40	40	40	40

- i. Are your diagrams consistent with the results?
- ii. If not, what must occur to obtain the results of Experiment 2?
- iii. What do the results of Experiment 2 suggest about the distance between the genes that regulate body color and wing type?

Question 3

You are working with flies that can be broadly categorized as **aggressive** or **mild** and **red** or **grey**. You decide to study the genes responsible for these two traits. **Note:** Use the letters "A", and "a" for temperament (aggressive or mild) and "B" and "b" for body color (red or grey). Use the uppercase letter to represent the alleles associated with the dominant phenotypes and the lowercase letters to represent the alleles associated with the recessive phenotypes.

a) You mate a true breeding **aggressive** and **red** fly with a **mild** and **grey** fly. You find that all the flies in the F1 generation are **aggressive** and **grey**. You take an F1 generation female fly and **test cross** her with a true breeding male fly and score 1600 progeny.

- i. Give the genotype and phenotype of the male fly in the **test cross**.

Phenotype:

Genotype:

Question 3 continued

- ii. If the genes regulating the two traits are **10cM** apart, write the genotypes and corresponding phenotypes of the different classes of flies that you would expect. Also write the approximate number of flies that you would expect for each class.

Genotypes	Phenotypes	Approximate Numbers

b) You are also interested in the additional following traits for the same flies.

- Antennae length, with long antennae being dominant (**N**) over short antennae (**n**).
- Wing size, with wings (**D**) being dominant over wingless (**d**).

You perform the following crosses.

- You cross a true breeding fly having grey body color and long antennae with a true breeding fly having red body color and short antennae. A test cross with a resulting F1 fly gives 320 recombinant progeny from a total of 1600 flies in F2.
- You cross a true breeding aggressive fly having long antennae with a true breeding mild fly with short antennae. A test cross with a resulting F1 fly gives 480 recombinant progeny from a total of 1600 flies in F2.
- You cross a true breeding grey fly having wings with a true breeding red, wingless fly. A test cross with a resulting F1 fly gives 640 recombinant progeny from a total of 1600 flies in F2.
- You cross a true breeding aggressive fly having wings with a true breeding mild, wingless fly. A test cross with a resulting F1 fly gives 800 recombinant progeny from a total of 1600 flies in F2.

Based on the results of the crosses above, answer the following questions.

- Which pairs of genes are exhibiting classical Mendelian inheritance?
- Draw a **chromosomal map** to show the approximate map distance between the genes for body color, temperament, antennae length and wing size.

Question 4

Your friend is studying two characteristics in mice: response to an infection (*susceptible or resistant*) and alertness (*alert or lazy*). Each of these traits is regulated by one gene. You cross a **true-breeding alert** mouse (mouse 1) that is resistant to infection with a **true-breeding lazy** mouse that is susceptible to infection (mouse 2). All of the resulting F1 mice are alert but susceptible to infection.

a) What are the **genotypes** of mouse 1 and mouse 2? **Note:** In each case, use the uppercase letter for the allele associated with the dominant phenotype and the lowercase letter for the allele associated with the recessive phenotype. For the response to an infection (i.e. susceptible or resistant) use *D* or *d* to designate the alleles. For alertness (i.e. alert or lazy) use *G* or *g* to designate the alleles.

Mouse 1:

Mouse 2:

Question 4 continued

b) You do a test cross with an F1 mouse and obtain 100 offspring. Assuming that the two genes are **unlinked**, give all possible genotypes and phenotypes of the mice that you will obtain in F2.

Phenotype of the F2 mice	Genotype of the F2 mice

c) If you obtain 100 mice in F2, approximately how many of these would be susceptible and alert?

d) You also want to study the following genes in the same mice.

- *A gene that regulates the fur color, which is either grey (dominant trait represented by allele A) or white (recessive trait represented by allele a). The map distance between this gene and the gene that regulates alertness is 20cM.*
- *A gene that regulates appetite, which is either hearty (dominant trait represented by the letter B) or weak (recessive trait, represented by the letter b). You find that the map distance between this gene and the gene that regulates fur color is 9cM.*

There are two genetic maps consistent with this information. Propose a mating experiment that would allow you to draw a genetic map showing the position of the genes regulating alertness, fur color and appetite. For each of the possible maps, give % of each class of progeny that would be consistent.

Question 5

As a plant geneticist, you have identified three traits that contribute to the taste of certain coffee beans. You isolate strains of coffee plants that breed true for each trait. The strains produce beans that can be either nutty or plain (use A or a); 2) bitter or smooth (use B or b); and caffeinated or decaffeinated (use D or d). **Note:** *In each case, use the uppercase letter for the allele associated with the dominant phenotype and the lowercase letter for the allele associated with the recessive phenotype.*

You cross a true breeding nutty, smooth, decaffeinated strain to a true breeding plain, bitter, and caffeinated strain. You obtain 100 plants in F1 generation with the following traits.

20 nutty, bitter, caffeinated

80 nutty, smooth, caffeinated

a) Which of the above traits are **NOT** exhibiting classic Mendelian inheritance?

Question 5 continued

b) Which traits are **dominant** Mendelian traits?

c) You cross two F1 plants:

nutty, bitter, caffeinated X nutty, smooth, caffeinated

If there are 640 plants in the F2 generation, give **all** the possible phenotypic classes you expect to see. Give the total number and the ratio of progeny in each phenotypic class. *Note: Please ignore the traits that do not exhibit Mendelian inheritance.*

Question 6

In this exercise you will use StarGenetics, a software that simulates mating experiments to analyze the nature and mode of inheritance of specific genetic traits. To get to StarGenetics, please navigate to <http://web.mit.edu/star/genetics>. Click on the **Start** button to launch the application. Allow the application to run on the computer. Click on **File -> New** on the main menu. On the **Welcome** page, click on **Fruit fly Exercise -3**.

You catch two fruit flies; one of these flies is male and the other is female. Both flies have a very unusual phenotype: **blue eyes** and **white body color**. You put these flies in a vial and several days later, you return to find that this vial is full of blue-eyed, white-bodied flies! The two flies that you caught have mated and it turns out that they are **true breeding** for the alleles that determine **eye and body color**! You decide to find out if the genes that determine these two traits are linked or unlinked. When you come back to the lab, you discover that all of your blue-eye, white-body color flies have died except for one female. You are determined to test for gene linkage, though. To do so, you need to accomplish the following two tasks:

- *First, you need to generate more blue-eye, white-body color flies by designing mating experiments using your one remaining blue-eye, white-body color female and a common laboratory fruit fly stock with a well characterized genetic background.*
- *Following this, you can perform mating experiment to determine if the two genes that determine the traits of interest are linked.*

a) Give the phenotype of the two flies in the **“strains window”** available for your initial mating experiment. *Note: Click on each fly to view its phenotype.*

Male Fly:

Female fly:

b) To generate more flies with blue eyes and white body color, you set up a mating experiment between the two available flies. *Note: You can set up a mating experiment by dragging the chosen parent flies to the Mating site and then clicking on the **“MATE”** button. Mating results are summarized in the **“SUMMARY”**. You can view the phenotypes by clicking the **“SUMMARY->SHOW TAB”** tab.*

- i. Describe the different phenotype(s) that you observe among the 50 F1 progeny and indicate how many of each type you observe.

Question 6 continued

- ii. Indicate which phenotypes for eye and body color are **dominant** and which are **recessive**.
- iii. The genes regulating which trait (*choose from body color or eye color*) are located on the X chromosome?

c) Indicate genotypes for the following flies. **Note:** Use letters *B* and *b* for the alleles that regulate body color. Use letters *E* and *e* for the alleles that regulate eye color. For each gene, use the uppercase letter to represent the allele associated with the dominant phenotype and the lowercase letter to represent the allele associated with the recessive phenotype.

Individuals	Genotypes
Parent 1	
Parent 2	
Male F1 progeny	
Female F1 progeny	

d) Design a mating experiment that would enable you to confirm your answer to part b (iii). Indicate genotypes and phenotypes of the flies that you will mate. Diagram the mating experiment and predict the genotypes and phenotypes of the resulting progeny. **Note:** *This part of the question is optional and will not be graded.* You can choose and drag the fly from your experiment to the "MATING SITE". Click on "SAVE EXPERIMENT". To start a new mating experiment click on the "NEW EXPERIMENT" button and then click on the "MATE" button as described earlier.

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7.013 Introductory Biology
Spring 2013

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