Solution Key- 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.

> <u>**Light**</u>　　　　**Wingless**　　　　<u>**Normal wings**</u>　　　　**Dark**

b) Give the likely genotypes with respect to body color and wing type for the following flies. *<u>Note:</u>*
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 <u>**P1**</u> **Fly**:　*AaBb*　　　　　**Genotype** of <u>**P2**</u> **Fly:**　*Aabb*
>
> **Genotype** of <u>**P3**</u> **Fly**:　*aabb*　　　　　**Genotype** of <u>**P4**</u> **Fly:**　*AABB*

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

   i.　　Is homozygous at only **one** locus?　*P2*

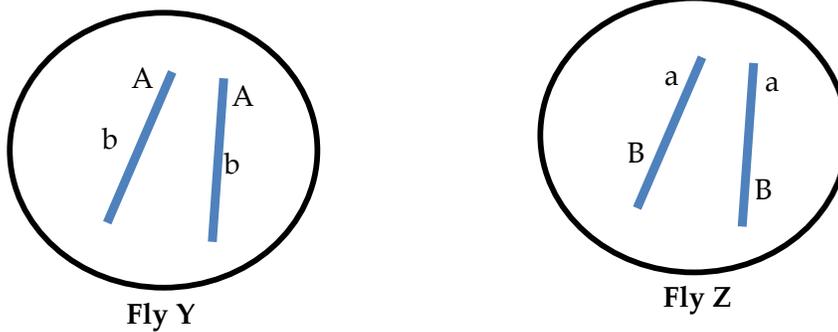   ii.　　Is homozygous at **both** loci?　*P3 & P4*

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.
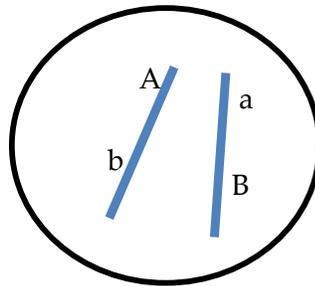*You would mate your test fly with P3 fly since this fly will produce gametes that have the genotype "ab" i.e. gametes that have alleles that regulate the recessive phenotypes. When these gametes will fuse with the gametes from the test fly, the resulting progeny will show all the possible genotypes of the test fly.*
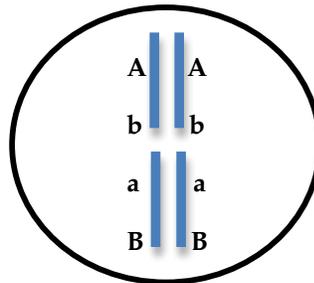
Question 2

a) Below is a schematic of diploid nuclei **prior to DNA replication** from <u>flyY</u> **with genotype AAbb**, and from <u>flyZ</u> **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.

Fly Y

Fly Z

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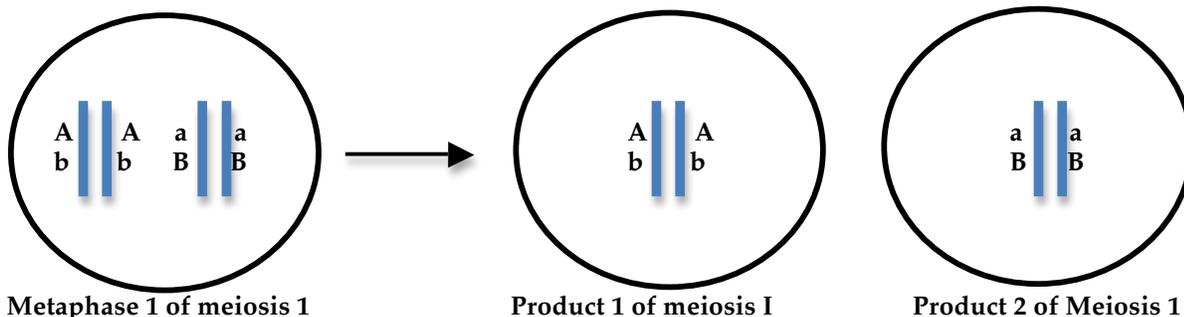

c) Now consider the diploid nucleus drawn in part (b) during **mitosis**. Draw and align the chromosomes as they would appear during metaphase of **mitosis**. Include the A, a, B, and b alleles on the drawing.
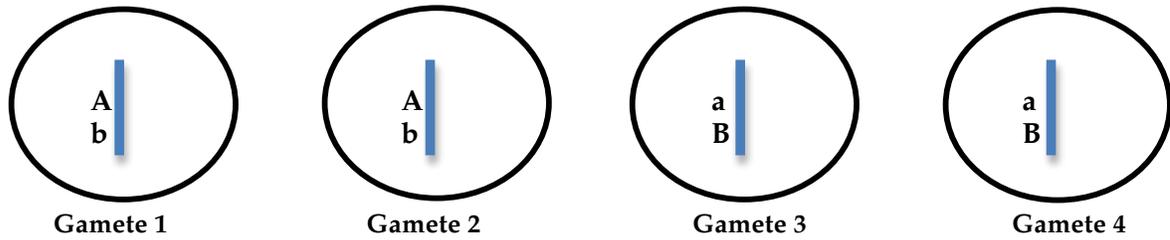

d) Now consider the diploid nucleus drawn in (b) above during **meiosis**.

i. On the diagram below, draw and align the chromosomes as they 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.**

Metaphase 1 of meiosis 1

Product 1 of meiosis I

Product 2 of Meiosis 1

2

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 on each 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.

There are two possibilities.

Possibility 1: *If you have drawn product 1 of meiosis 1 as the one shown in this solution key then you will get four gametes with the following genotypes.*

Gamete 1 having genotype "AAbb", Gamete 2 lacking the chromosome that has these two genes (most likely this gamete will not be viable), Gamete 3 having genotype "aB", Gamete 4 having genotype "aB.

Possibility 2: *If you have drawn product 1 of meiosis 1 as the one shown as product 2 in this solution key then you will get four gametes with the following genotypes.*

Gamete 1 having genotype "aaBB", Gamete 2 lacking the chromosome that has these two genes (most likely this gamete will not be viable), Gamete 3 having genotype "Ab", Gamete 4 having genotype "Ab.

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?
No, these diagrams are not consistent with the above results since you are getting only two sets of gametes one set having genotype "Ab" and the other having the genotype "aB". In order to get the result shown in the table above you need to have four gametes of genotypes "Ab", "aB", "AB" and "ab". When a fly producing these gametes is crossed with a double homozygous recessive fly having the genotype "aabb" that produce four gametes all have the same genotype (ab) you can get four different phenotypic classes that are outlined in the table.

ii.   If not, what must occur to obtain the results of Experiment 2?
You can get 4 gametes each having a different genotype if and only if there occurs recombination event or crossing over between the two non-sister chromatids of the homologous chromosomes during meiosis 1.

iii.   What do the results of Experiment 2 suggest about the distance between the genes that regulate body color and wing type?
It suggests that the two genes in question are located on the same chromosome but they are 50 map units or 50cM apart that allows them to recombine to produce four gametes with equal frequency each having a different genotype i.e. these genes are unlinked and they assort as per the Mendelian genetics.

3

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: _mild & red_   **Genotype:** _aabb_

   ii. If the genes for the two characters (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
Abab	_Aggressive, red_	_720_
aBab	_Mild, grey_	_720_
ABab	_Aggressive, grey_	_80_
abab	_Mild, red_	_80_

b) You are also interested in the additional following traits for the same flies.
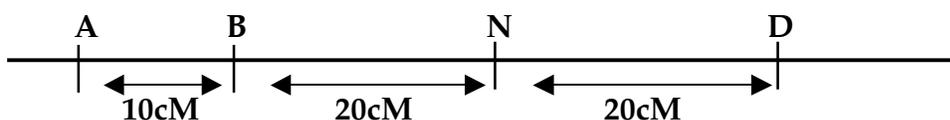
   - Antennae length, with long antennae being dominant (**N**) over short antennae (**n**).
   - Wing size, with wings (**D**) being dominant over wingless (**d**).

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.

   i. Which pairs of genes are exhibiting classical Mendelian inheritance?
   A and D genes since they are 50 CM apart.

   ii. Draw a **chromosomal map** to show the approximate map distance between the genes for body color, temperament, antennae length and wing size.

A   B   N   D

10cM   **20cM**   **20cM**

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: | *ddGG* | **Mouse 2:** | *DDgg* |

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
Susceptible and lazy	*Dgdg*
Alert and resistant	*dGdg*
Alert and susceptible	*DGdg*
Lazy and resistant	*dgdg*

c) If you obtain 100 mice in F2, approximately how many of these would be susceptible and alert?
   25

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). T**he map distance between this gene and the gene that regulates alertness is 20cM.***

- *A gene that regulates appetite, which is either hearty (dominant trait represent 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.
The two possibilities are shown below:

(i): (Gene regulating appetite)——9cM——(Gene regulating fur color)————20cM————(Gene regulating alertness)
        alleles: B, b   alleles: A, a   alleles: G, g

(ii): (Gene regulating fur color)——9cM——(Gene regulating appetite)——11cM——(Gene regulating alertness)
        alleles: A, a   alleles: B, b   alleles: G, g

You can set up one of the following two mating experiments:
Experiment #1: *Mate a true- breeding hearty/ susceptible mouse (genotype: BBGG) with a true- breeding weak/alert mouse (genotype: bbgg) to obtain hearty/ susceptible mice (genotype: BbGg) in F1 generation. Now mate an F1 mouse with a true- breeding weak/ alert mouse (genotype: bbgg). You will get 29% recombinants (hearty/ alert; genotype Bgbg and weak/ susceptible; genotype bGbg) if possibility (i) is correct or 11 %recombinants (recombinants (hearty/ alert; genotype Bgbg and weak/susceptible; genotype bGbg) if possibility (ii) is correct.*

Question 4 continued

Experiment #2: Mate a true-breeding hearty/alert mouse (genotype: BBgg) with a true-breeding weak/susceptible mouse (genotype: bbGG) to obtain hearty/susceptible mice (genotype: BbGg) in F1 generation. Now mate an F1 mouse with a true-breeding weak/alert mouse (genotype: bbgg). You will obtain 29% recombinants (hearty/susceptible; genotype BGbg and weak/alert; genotype bgbg) if possibility (i) is correct or 11 %recombinants (hearty/susceptible; genotype BGbg and weak/alert; genotype bgbg) if possibility (ii) is correct.

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. The first (F1) generation is 100 plants:

20 nutty, bitter, caffeinated

80 nutty, smooth, caffeinated

a) Which of these traits are **NOT** exhibiting classic Mendelian inheritance? *Taste (bitter or smooth)*

b) Which traits are **dominant** Mendelian traits? *Nutty and caffeinated*

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.*

The four different classes in F2 and their corresponding ratios would be Nutty and caffeinated: Nutty and decaffeinated: plain and caffeinated: plain and decaffeinated = (9:3:3:1)

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:

Question 6 continued

- *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: *Grey body & red eye*   **Female fly:** *White body color and blue eye*

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 on the Summary. You can also 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.
      32 males with grey body color and blue eyes and 28 females with grey body color and red eye (__Note:__ the numbers can be different for each experiment but the ratio should be approx 1:1).

   ii.   Indicate which phenotypes for eye and body color are **dominant** and which are **recessive**.

      Grey body color is dominant to white body color and red eye color is dominant to blue eye color.

   iii.   The genes regulating which trait (*choose from body color or eye color*) are located on the X chromosome? *Eye color*

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 upper case 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	*bbX^eX^e or bbee*
Parent 2	*BBX^EY or BBEY*
Male F1 progeny	*$Bb^{Xe}Y$ or BbeY*
Female F1 progeny	*$BbX^EX^{e\ or}$ or BbEe*

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.*

Cross female F1 progeny to Parent 2. We expect to see that all progeny are gray-bodied. All females should have wild-type eyes, while 50% of males will have blue eyes and 50% of males will have wild- type eyes. The expected genotype frequencies are:

Alleles of the gene regulating body color: *50% of flies BB, 50% of flies Bb (true for both sexes, all cases; all are gray)*
Alleles of the gene regulating eye color: *50% of females X^EX^E, 50% of females X^EX^e (all have wild- type eyes)*
                                      50% of males X^EY (wild- type eyes), 50% of males X^eY (blue eyes)

7.013 Introductory Biology
Spring 2013