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7.014 Problem Set 6

Please print out this problem set and record your answers on the printed copy.

Problem sets will not be accepted late.

Question 1

a) Define the following terms:

Dominant –

Recessive –

Phenotype –

Genotype –

Alleles –

Homozygous –

Heterozygous –

Mendel's First Law –

Mendel's Second Law –

Sex-Linked –

Haploid –

Diploid –

Question 1, continued

b) One summer, you decide to become an UROP student for a professor who studies the genetics of corn, *Zea mays*. When you cross the following a true-breeding strain of corn with purple, smooth kernels to a true-breeding strain of corn with yellow, wrinkled kernels you find that the F₁ progeny all have purple, smooth kernels. You then cross two F₁ progeny and see the following in the F₂ generation.

P₀ Phenotype

Purple, Smooth Kernels

Yellow, Wrinkled Kernels

P₀ Genotypes**

F₁ Phenotype

Purple, Smooth Kernels

F₂ Genotype**

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F₂ Phenotypes*

Yellow, Wrinkled Kernels

Yellow, Smooth Kernels

Purple, Smooth Kernels

Purple, Wrinkled Kernels

of F₂ Progeny

56,251

167,879

508,746

170,435

F₂ Genotypes**

i) Does the pattern above indicate a Mendelian method of inheritance for the traits of kernel color and kernel texture? Explain.

ii) Kernel color is encoded by gene A, where A is associated with the dominant phenotype and a is associated with the recessive phenotype. Similarly, kernel texture is encoded by gene B, where B is associated with the dominant phenotype and b is associated with the recessive phenotype. Indicate the genotype(s) for each of the corn plants in the above boxes under **Genotypes****.

Question 1, continued

c) You are unsure of the genotype of an individual F_2 corn plant (from Part b) that has purple, smooth kernels and would love to know its genotype.

i) What cross would allow you to determine the genotype of the purple, smooth corn plant?

ii) Describe the **four** different possible **scenarios** from your cross above. **Indicate phenotypes and genotypes.**

Question 2

The fruitfly *Drosophila melanogaster* has been a focus of genetic studies since the early twentieth century with the pioneering experiments of Thomas Hunt Morgan. It is a good system for genetic studies because of its small size, ease of cultivation, and short generation time.

As a junior Drosophologist, you discover a mutation that results in flies with curly wings. You gather 30 curly-winged flies and perform the following P_0 and F_1 crosses and receive the results below:

P_0	30 curly-winged flies × 30 normal-winged flies	
F_1	603 curly-winged flies	197 normal-winged flies

You then perform several self-crosses with the two kinds of F_1 flies

	Self-Cross of curly-winged flies	Self-Cross of normal-winged flies
F_2	598 curly-winged flies & 205 normal-winged flies	All normal-winged flies

a) **Is the curly-winged phenotype dominant or recessive?**

Question 2, continued

b) The curly phenotype follows a Mendelian mode of inheritance, so why don't the numbers of offspring follow Mendelian ratios?

c) Enamored by the robustness of *Drosophila* genetics, by the cuteness of curly-winged flies, and by the prospects of an entrepreneurial venture selling flies to frog and lizard pet owners, you decide to breed flies with altered wings. (FYI: Curly- and short-winged flies do not fly as well as normal-winged flies so frogs and lizards can feed easily.) You create two different pure-breeding strains of short winged flies and call them *sht1* and *sht2*. In both strains, the short-winged phenotype is recessive.

i) What experiment would allow you to determine whether these two strains carry mutations in the same gene or in two different genes? What results would you expect if the two strains have mutations in different genes?

d) You identify mutations in two genes that result in the following recessive phenotypes: (1) flies homozygous for *dbl1* have double-wings and (2) flies homozygous for *prpl1* have purple eyes rather than red eyes. You then perform the following cross:

Normal-winged, Red-eyed flies $dbl1^+ \quad dbl1^- \quad prpl1^+ \quad prpl1^-$	×	double -winged, Purpled-eyed flies $dbl1^- \quad dbl1^- \quad prpl1^- \quad prpl1^-$
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i) What would the phenotypic ratios of the progeny be if *dbl1* and *prpl1* were unlinked genes?

ii) Instead of finding that the genes *dbl1* and *prpl* are unlinked, you find that *dbl1* and *prpl1* are linked. When you perform the above cross, you find the following progeny:

68 normal-winged, red-eyed flies
 73 double-winged, purple-eyed flies
 6 normal-winged, purple eyed flies
 9 double-winged, red-eyed flies

Calculate the recombination frequency between the *dbl1* and *prpl1* genes

Question 3

There are four blood types in human: A, B, AB, and O. This is a single gene trait with three alleles. The A and B blood types (associated with alleles I^A and I^B , respectively) are both dominant to the O blood type (associated with i allele). The A and B blood types are co-dominant to each other. You are a genetic counselor and physician at the Massachusetts General Hospital. The combinations for genotypes and phenotypes are listed below:

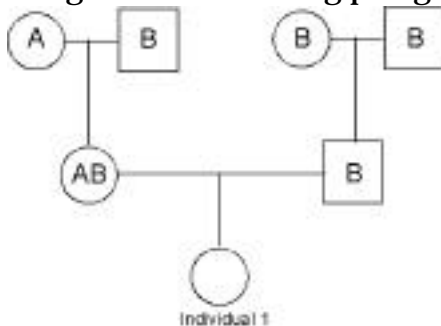
Genotype	Phenotype
$I^A I^A$ and $I^A i$	A
$I^B I^B$ and $I^B i$	B
$I^A I^B$	AB
ii	O

a) One of your female patients makes an inquiry to see if her friend was actually the father of her child. The mother is blood type B and the child is blood type O.

i) Unfortunately, the possible father was killed while performing dangerous genetic experiments with corn and fruitflies. Your patient believes that this man had blood type A. Would this information exclude this man as the father of the child? Explain.

ii) Luckily, the possible father's parents are still alive and they submit blood samples to be tested: his father and mother are both blood type AB. You also find records that the possible father was actually blood type A. Is the accused father the actual father of the child? Explain.

b) You are given the following pedigree for family blood types:



i) If Individual 1 is blood type B, what is the probability that she will have the genotype $I^B i$?

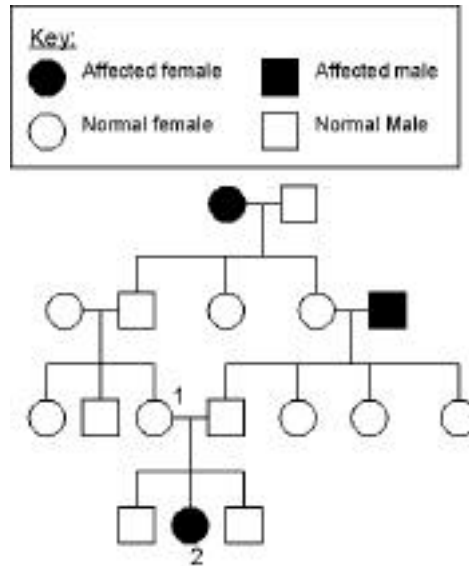
ii) The parents of Individual 1 now have a newborn child that is blood type A. What is the probability that Individual 1 would have the genotype $I^A I^B$?

Question 3, continued

c) For the following pedigrees determine:

- i) The most likely mode of inheritance (e.g., dominant, recessive, autosomal, X-linked, new mutation, etc.) of the genetic disease
- ii) The probable genotype of the numbered individual(s). Indicate any ambiguities. Be sure to define your genotype symbols clearly.

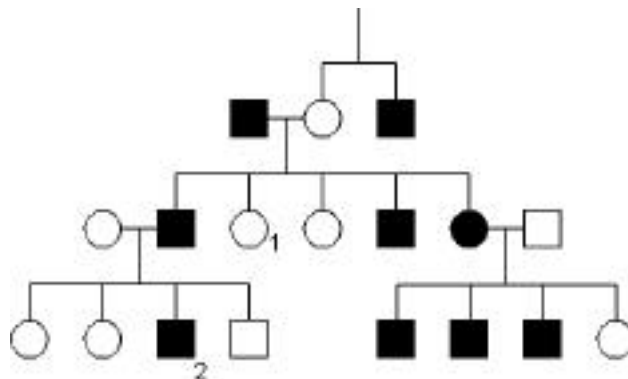
Disease A Pedigree



i) Mode of inheritance:

ii) Genotypes:

Disease B Pedigree

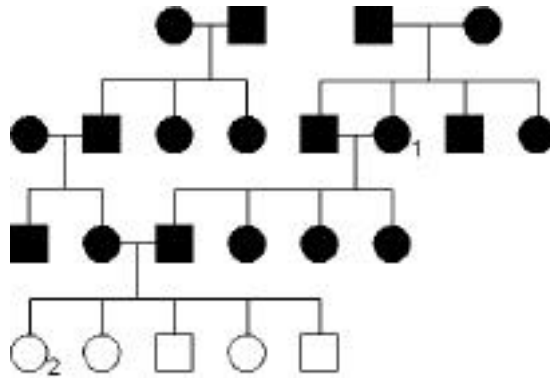


i) Mode of inheritance:

ii) Genotypes:

Question 3, continued

Disease C Pedigree



i) Mode of inheritance: (Hint: Think complementation)

ii) Genotypes:

Question 4

You are now studying the process of mitosis and meiosis in the simple organism, *Notuu briitus*, and have prepared microscope slides of fixed (preserved) and treated these cells with DAPI, a chemical that will mark chromosomes/DNA of a cell under fluorescent microscopy. *N. briiitus* only have two chromosomes. You also have the ability identify the location of two unlinked genes, A and B (A is dominant, a is recessive; B is dominant b is recessive); this facilitates your ability to genotype the cells. You have forgotten to label your slides while preparing them and attempt to sort the stage of the cell cycle that each may contain: G1, S, G2, Mitosis (Prophase, Metaphase, Anaphase, Telophase), Meiosis (Prophase I, Metaphase I, Anaphase I, Telophase I, Prophase II, Metaphase II, Anaphase II, Telophase II), or cytokinesis.

Answer the following questions to determine the characteristics of the slide that you are viewing under the microscope.

a) Slide 1: You look in the microscope and find a single cell with decondensed chromosomes. The genotype of the cell is AAaBBbb.

i) Does the cell have a 1n, 2n or 4n amount of DNA?

ii) What phase of the cell cycle does this belong to?

b) In the space below, draw what you would see in the scope. Indicate where the alleles—A, a, B, and b—are located on the chromosomes.

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Question 4, continued

c) Slide 2: You look in the microscope and find all chromosomes are aligned at the center of a single cell. The genotype of the cell is AAaaBBbb.

- i) Does the cell have a 1n, 2n or 4n amount of DNA?

- ii) What phase of the cell cycle does this belong to?

- iii) If the cell completed its current path along the cell cycle what would be the genotypes of the resulting cells.

- iv) In the space below, draw what you would see in the scope in slide 2. Indicate where the alleles—A, a, B, and b—are located on the chromosomes.

d) Slide 3: On this slide, you find two cells where sister chromatids are paired but are beginning to be pulled to one side of the chromosome by the spindle located on either side of the cell poles. The genotype of one cell is AAbb. The other cell is aaBB.

- i) Does the cell have a 1n, 2n or 4n amount of DNA?

- ii) What phase of the cell cycle do these cells belong to?

- iii) If the cell completed its current path along the cell cycle what would be the genotypes of the resulting cells.

- iv) In the space below, draw what you would see in the scope. Indicate where the alleles—A, a, B, and b—are located on the chromosomes.

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Question 4, continued

e) Slide 4: In the following slide, you see four cells that have just completed cytokinesis. The genotypes of the cells are as follows: AB, aaB, Ab, b.

i) What is wrong with these cells?

ii) What phase of the cell cycle could this defect have occurred (Interphase, Mitosis, Meiosis I, Meiosis II)?

iii) In the space below, draw what you would see in the scope. Indicate where the alleles—A, a, B, and b—are located on the chromosomes.