Name Claire Hathaway

1. (4 pts) For a population NOT in Hardy-Weinberg equilibrium, in how many generations, and under what conditions, could the population reach Hardy-Weinberg equilibrium?

A. 2 generations, inbreeding
B. 4 generation, natural selection
C. 1 generation, random mating
D. 1 generation, founder effect
E. Cannot be determined from this data

2. (4 pts) You recently isolated two temperature sensitive (ts) mutants in the T4 phage. These ts mutants are lethal when grown at high temperature but can survive at low temperature. To test if these ts mutants are in the same gene, which of the following statement is **correct**?

complementation

a. Cross both mutants at low MOI at low temperature. If high titer of progeny is observed, the two ts mutants are in the same genes.

b. Cross both mutants at high MOI at high temperature. If no progeny is observed, the two ts mutants are in the same genes.

c. Cross both mutants at high MOI at low temperature. If high titer of progeny is observed, the two ts mutants are in the same genes.

d. Cross both mutants at low MOI at high temperature. If no progeny is observed, the two ts mutants are in the same genes.

3. (5 points) The results of complementation tests between eight bacteriophage mutants (1 to 8) are shown below. The experiments determine whether the mutants complement one another (+) or fail to complement (-). These eight mutants are known to result from point mutation.

	1	2	3	4	5	6	7	8
1	-	+	+	+	-	+	+	-
2		-	+	+	+	+	+	+
3			-	+	+	+	-	+
4				-	+	-	+	+
5					-	+	+	-
6						-	+	+
7							-	+
8								-

1 2 3 4
5 7 6
8

Based on the complementation test results, how many genes are represented by these mutations? (circle correct answer)

1 **2** **3** **4** **5** **6** **7**

Name Claire Hathaway

4. In a large population, about 1/8 of males have red-green colorblindness, an X-linked recessive trait.
4a. (5 pts) What fraction of females will have the trait?

Answer = 1/64 1/8 of males q^Y $q = 1/8 = 0.125$

females → $q^2 = 0.0156 = 1/64$

4b. (6 pts) In a mating between a colorblind male and a female who is not colorblind, what is the chance that their first child will be colorblind? Do not assume that p=1.

Answer = 1.36%. q^Y $2pq$

$q = 0.125$ $p = 0.875$

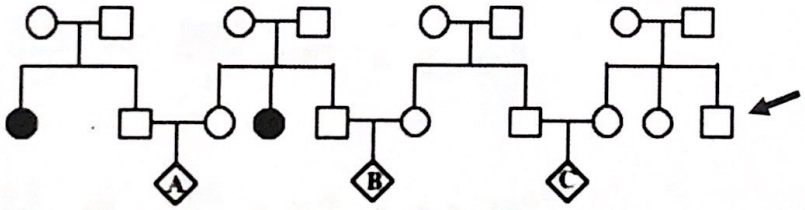
	A	a
a	Aa	aa
Y	AY	aY

~~$q^Y \times 2pq \times 1/2$~~

$(0.125) \times (2)(0.875)(0.125) \times 1/2 = 0.0136 \rightarrow$ 1.36%.

+2 +2

5. (4 pts) Below is a pedigree from an extended family that is afflicted with an autosomal recessive genetic disease. The frequency of **carriers** in the population that this family lives in is 1 in 100. Three couples in the pedigree are expecting their first child. **Which of the following statements is incorrect?**



$f(Aa) = 1/100$

a. The probability for II-10 (arrow) to be a carrier is 0.01

b. The probability for C to be afflicted by this disease is 1/4,000. 2.5×10^{-4} $1/100 \times 1/100 \times 1/4 = 2.5 \times 10^{-5}$

c. Among A, B and C, A has the highest chance to be afflicted by this disease.

d. The probability for B to be afflicted by this disease is 1/600. $2/3 \times 1/100 \times 1/4 = 0.00166$

↓

0.00166

Name Claire Hamaway

6

6. (6 pts) Within a certain population (in Hardy-Weinberg equilibrium) the frequency of the L allele of the LM blood group is 0.2 and the frequency of the M allele is 0.8. This population has just been infected with a virus that kills everyone with blood type LM, but individuals with blood type L or M are unaffected by the virus. What is the allele frequency of L and M in the population immediately after the viral infection. Show your work and circle your answer.

Answer = L = 0.058, m = 0.941 L = 0.2, m = 0.8 LM lethal

0.04 + 0.64 = 0.68

$LL = \frac{0.04}{0.68} = 0.058$ $mm = \frac{0.64}{0.68} = 0.941$

		0.2 L	0.8 m
0.2	L	LL 0.04	~~LM~~
0.8	m	~~LM~~	mm 0.64

In a population of 100:

LL → 5.8, mm → 94.1

$P(L) = \frac{5.8 + 5.8}{200} = \boxed{0.058}$ $P(m) = \frac{94.1 + 94.1}{200} = \boxed{0.941}$

6

7. (6 pts) E. coli strain B is doubly infected with two rII mutants of phage T4. 0.1 ml of a 10^6 dilution of the progeny is plated on E. coli B and 0.1 ml of a 10^4 dilution of the progeny is plated on E. coli K. 300 plaques appeared on strain B, 60 on strain K. Calculate the map distance between these two mutations. Show your work and Circle your answer.

Answer = 0.4 m.u.

B: 0.1 ml of 10^6 → 300 K: 0.1 ml of 10^4 → 60

B: $\frac{300}{0.1} \rightarrow \frac{3000}{1} \times 10^6 = 3 \times 10^9$

K: $\frac{60}{0.1} \rightarrow \frac{600}{1} \times 10^4 = 6 \times 10^6$

recombination: $\frac{(6 \times 10^6 + 6 \times 10^6)}{3 \times 10^9} = 0.004 \rightarrow \boxed{0.4 \text{ m.u.}}$

Name Claire Hathaway

8. (12 pts) You want to map the a, b, and c genes by an Hfr interrupted mating experiment. Without knowing the order of the genes, you cross **Hfr $a^+b^+c^+$ str^S x F^- $a^-b^-c^-$ str^R.** str^R encodes resistance to the antibiotic streptomycin.
The a^+ gene is required for biosynthesis of nutrient A, the b^+ gene for nutrient B, and the c^+ gene for nutrient C. The minus alleles are auxotrophs for these nutrients. The cross is initiated at time = 0, and at various times the mating mixture is plated on three types of medium. Each plate contains minimal medium plus streptomycin plus specific supplements indicated in the following table. The results at each time point are shown as the number of colonies growing on each plate.

Supplements added to MM		**5min**	**10min**	**15min**	**20min**
Nutrients A and B	C	**0**	**0**	**4**	**21**
Nutrients B and C	A	**4**	**25**	**60**	**82**
Nutrients A and C	B	**0**	**5**	**23**	**40**

(8a. 4 pts) What is the purpose of streptomycin in the experiment? 10 words or fewer.

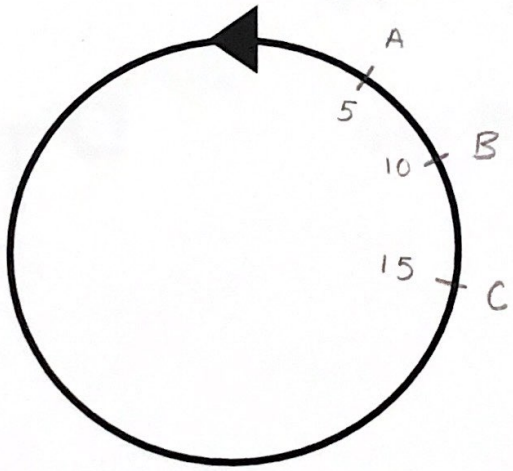
To kill the Hfr

(8b. 4 pts) What genotype(s) of bacteria can grow on a plate containing nutrients A and C? [circle all correct answer(s)]

all A & C ; B^+ only

$a^+b^+c^+$ $a^+b^+c^-$ $a^+b^-c^+$ $a^+b^-c^-$ $a^-b^+c^+$ $a^-b^+c^-$ $a^-b^-c^+$ $a^-b^-c^-$

(8c. 4 pts) Based on these data, use the map provided below to indicate the approximate location (time of entry) on the chromosome of the *a, b,* and *c* genes relative to one another and to the Hfr origin of replication (arrowhead).



Name Claire Hathaway

6 **9. (6 pts)** In a particular population the allele frequency of the ABO blood type alleles are as follows: I^A is 30%, I^B is 40% and i is 30%. If mating is random and the population is in Hardy-Weinberg equilibrium, what percent of the population will have blood type A?

Answer = 27%

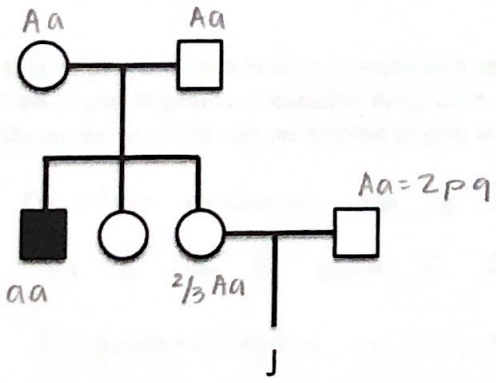
A: AA Ai

		0.3 A	0.4 B	0.3 i
0.3	A	AA 0.09	AB	Ai 0.09
0.4	B	AB	BB	Bi
0.3	i	Ai 0.09	Bi	ii

0.09 + 0.09 + 0.09 = 0.27 ↓ 27%

6 **10. (6 pts)** In a large randomly mating population that is in Hardy Weinberg Equilibrium, the incidence of an autosomal recessive disease is 1 in 8100 individuals. Given this pedigree, what is the probability that J will have the disease?

Answer = 356/97200



$q^2 = 1/8100$

$q = 1/90$, $p = 89/90$

$2pq = 178/8100$

$2/3 \times 178/8100 \times 1/4 = 356/97200$

OR

0.00366

Name Claire Hathaway

8

11a. (8 pts) Below is a set of recombination and complementation data between six mutants of the rII locus of phage T4. Determine the best map possible, showing gene order and cistron boundaries. **Mutant #1 is in the rIIA cistron. Put parenthesis** around groups of mutants whose order is ambiguous. For the complementation test, a (+) indicates the mutants complement; a (–) indicates they do not complement. For the recombination test, a (+) indicates the mutants can recombine to give a wild type recombinant; a (–) indicates they cannot recombine to give wild type recombinants.

Complementation Test

	1	2	3	4	5	6
1	–	+	–	–	+	–
2		–	+	–	–	+
3			–	–	+	–
4				–	–	–
5					–	+
6						–

Recombination Test

	1	2	3	4	5	6
1	–	+	+	+	+	+
2		–	+	–	+	+
3			–	–	+	+
4				–	+	+
5					–	+
6						–

A	B
1	2
3	5
4	4
6	

(1,6) 3 | 2 5

4

4 **11b. (4 pts)** Describe how you would do a recombination test between mutant #3 and mutant #5 (feel free to use diagrams to explain). Also, what result from the recombination test would tell you that these two mutants can recombine to give wild type progeny. **(30 words or less)**

Coinfect mutants on E. Coli B at high m.o.i. Plate progeny on E. Coli B and E. Coli K.

If plaques grow on K, the mutants are at different locations and can recombine to make WT.

Name Claire Hathaway

12. (12 pts) Enzymes A, B, C and D control the production of a brown pigment in a plant. The genes encoding A, B, C and D are independently assorting genes. The alternate alleles that give abnormal functioning of these genes are a, b, c and d. A brown **AA BB CC DD** is crossed with a white **aa bb cc dd** to give a brown F1. The F1 are then **selfed** to form the F2. Assume that A, B, C and D act in a pathway as follows:

white $\xrightarrow{A}$ olive $\xrightarrow{B}$ grey $\xrightarrow{C}$ grey $\xrightarrow{D}$ brown

12a. (6 pts) What percentage of the F2 are olive? **SHOW WORK**

Answer = 18.75%.

AaBbCcDd x AaBbCcDd

	Aa
A	AA Aa
a	Aa aa

A_bb $(3/4)(1/4) = 0.1875$

18.75%.

12b. (6 pts). What percentage of the F2 are grey? **SHOW WORK**

Answer = 24.61%.

AaBbCcDd x AaBbCcDd

	A	a
A	AA	Aa
a	Aa	aa

A_B_cc $(3/4)(3/4)(1/4) = 0.1406$

A_B_C_dd $(3/4)(3/4)(3/4)(1/4) = 0.1055$

$0.1406 + 0.1055 = 0.2461 \rightarrow$ 24.61%.

Name Claire Hathaway

13. (12 pts) The *r1*⁻ mutant of phage T4 has a large plaque phenotype, whereas wild type phage make a small plaque. The ts1⁻ mutant can grow at 30°C but not at 40°C, whereas wild type phage can grow at both temperatures. You want to determine the recombination frequency between r1 and ts1. An *E. coli* strain is coinfected at high m.o.i. at 30°C with a wild type phage stock and with a phage stock that contains both the r1 and ts1 mutations.

r1⁻ ts1⁻ x r1⁺ ts1⁺

The progeny is titered and plated at both 30°C and 40°C with the following results. The frequency of phage with large plaques and small plaques is shown for both temperatures.

Phenotype	30°C	40°C
Large plaques	**8 x 10^8 pfu/ml**	**2 x 10^8 pfu/ml**
Small plaques	**8 x 10^8 pfu/ml**	**6 x 10^8 pfu/ml**

total: 16×10^8

What is the recombination frequency between the r1 and ts1 genes? (Show your work).

Answer = 25 m.u.

r1⁻ large

r1⁺ small

ts1⁻ 30°C

ts1⁺ 30°C & 40°C

large/30°C → r1⁻ ts1⁺ or r1⁻ ts1⁻

large/40°C → r1⁻ ts1⁺

small/30°C → r1⁺ ts1⁺ or r1⁺ ts1⁻

small/40°C → r1⁺ ts1⁺

large 30 - large 40 = r1⁻ ts1⁻

small 30 - small 40 = r1⁺ ts1⁻

r1⁻ ts1⁻ 6×10^8

r1⁺ ts1⁺ 6×10^8

r1⁺ ts1⁻ 2×10^8] recombinants

r1⁻ ts1⁺ 2×10^8]

$$\frac{(2 \times 10^8 + 2 \times 10^8)}{16 \times 10^8} = 0.25 = \boxed{25 \text{ m.u.}}$$

Name Claire Hathaway

X

14. **Extra credit (4 pts)**

There are adjacent islands that have two populations of dogs. On Island X, 91% of the dogs have black fur and 9% have white fur. On Island Y, 64% of the dogs have black fur and 36% have white fur. Both populations are in Hardy Weinberg equilibrium. Your analysis has shown that fur color is controlled by a single autosomal gene named gene A, with a dominant "A" allele causing black fur and the recessive "a" allele causing white fur.

You take 1000 random males from Island X and mate them to 1000 random females from Island Y. What percent of the offspring do you predict will have white fur?

Answer = 22.5%.

Island X: 91% black, 9% white

$A = 0.91$ $a = 0.09$

Island Y: 64% black, 36% white

$A = 0.64$ 0.36

Merged: $A = (0.91 + 0.64)/2 = 0.775 \rightarrow 77.5\%$ black

$a = (0.09 + 0.36)/2 = 0.225 \rightarrow 22.5\%$ white