Student name_____

BICD100 GENETICS
Prof. Reinagel

FINAL EXAM
Friday December 10, 2004
3:00PM – 6:00 PM

Sign this release if you want your exam left on 3rd floor of Pac Hall for you to pick up after it is graded:

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- This exam has 10 questions and is worth 50 points (half your grade). Notice that not all questions are worth equal points. Some questions have more than one page.

- Demonstrate your knowledge. To get full credit you must SHOW YOUR WORK. If you are stuck, try to put something that shows what you do know (or even why you are stuck).

- Pace yourself! Before you start working, write your name on every page and read through all the questions. Focus first on the questions that you find easy and the ones that are worth the most points.

- Try to relax!

_____ Question 1 (5pt)
_____ Question 2 (5pt)
_____ Question 3 (2 pt)
_____ Question 4 (5pt)
_____ Question 5 (6pt)
_____ Question 6 (2pt)
_____ Question 7 (5pt)
_____ Question 8 (4pt)
_____ Question 9 (6pt)
_____ Question 10 (10pt)
_____ Extra Credit

_____ TOTAL

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Question 1 (5 points. There are three parts a,b,c)

Here are some data from one of Mendel's experiments on pea plants:

A, form round ***a***, form wrinkled
B, albumen yellow ***b***, albumen green

Parents — ***AB*** X ***ab***

F1 appeared round and yellow

(self cross)

F2

315 round and yellow,
101 wrinkled and yellow
108 round and green,
32 wrinkled and green.

1a) What was the predicted phenotypic ratio based on equal segregation and independent assortment (Mendel's 1st and 2nd laws)?

1b) What are the genotype(s) of the wrinkled yellow progeny in the F2?

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1c) Using a Chi Square Test, what is the probability of the data being at least this far off from the prediction by chance, if the model is correct? SHOW YOUR WORK

Table 2-2 Critical Values of the χ^2 Distribution

	P									
df	0.995	0.975	0.9	0.5	0.1	0.05	0.025	0.01	0.005	df
1	.000	.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879	1
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597	2
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838	3
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860	4
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750	5
6	0.676	1.237	2.204	5.348	10.645	12.592	14.449	16.812	18.548	6
7	0.989	1.690	2.833	6.346	12.017	14.067	16.013	18.475	20.278	7
8	1.344	2.180	3.490	7.344	13.362	15.507	17.535	20.090	21.955	8
9	1.735	2.700	4.168	8.343	14.684	16.919	19.023	21.666	23.589	9
10	2.156	3.247	4.865	9.342	15.987	18.307	20.483	23.209	25.188	10
11	2.603	3.816	5.578	10.341	17.275	19.675	21.920	24.725	26.757	11
12	3.074	4.404	6.304	11.340	18.549	21.026	23.337	26.217	28.300	12
13	3.565	5.009	7.042	12.340	19.812	22.362	24.736	27.688	29.819	13
14	4.075	5.629	7.790	13.339	21.064	23.685	26.119	29.141	31.319	14
15	4.601	6.262	8.547	14.339	22.307	24.996	27.488	30.578	32.801	15

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Question 2. (5 points, There are four parts a,b,c,d)

You have a pure-breeding "wild-type" strain of peas which have yellow seeds, and three independently-derived pure-breeding strains that have green seeds. You cross each green-seeded strain to the yellow-seeded strain with the following results:

	green strain 1	green strain 2	green strain 3
Parental:	purebred green x purebred yellow	purebred green x purebred yellow	purebred green x purebred yellow
F1 phenotype:	yellow seeds	yellow seeds	green seeds
	Self cross F1	Self cross F1	Self cross F1
F2 phenotype:	3 yellow:1 green	3 yellow:1 green	1yellow: 3 green

2a) For each strain make up a symbol for the dominant and recessive alleles. State the symbols and the phenotype of each allele in the chart below. Use different symbols for the different strains.

	Dominant allele		Recessive allele	
	symbol	phenotype	symbol	phenotype
Strain 1				
Strain 2				
Strain 3				

2b) Using the symbols you defined in part (a), what is the genotype (or genotypes) of the green seeds in the F2 of each strain?

Strain 1

Strain 2

Strain 3

2c) If the F1 from strain 2 were crossed with the purebred green parent from strain 2, what phenotypic ratio do you expect in the progeny of that cross?

2d) You cross a purebred plant from green strain 1 with a purebred plant from green strain 2, and the resulting F1 plant has yellow seeds. When these F1 plants are allowed to self-fertilize, the F2 generation has a ratio of 9 yellow : 7 green seeds. Draw a Punnet square for the F1 self cross, showing the genotypes of each type of gamete, the diploid genotypes of each type of progeny, and circling the progeny genotypes that have the green phenotype.

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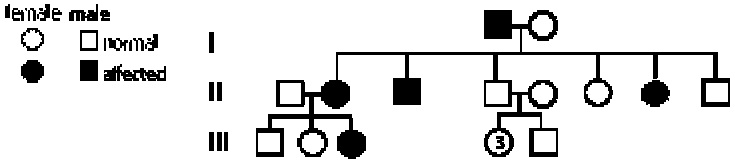
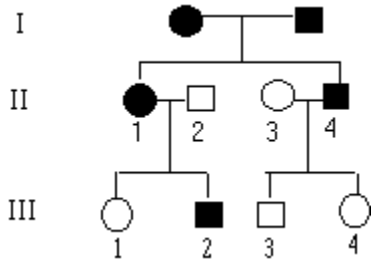
Question 3. (2 points, there are 2 parts a,b)

a) A family carrying a rare inherited disease presents with the following pedigree. What is the mode of inheritance of the disease?



b) The harmless trait in the pedigree below is inherited from a single dominant gene. If the cousins III-2 X III-4 have a child, what is the probability the child would have the trait? (SHOW YOUR WORK)



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Question 4. (5 points, there are 3 parts a,b,c)

In the fruit fly Drosophila, the genes a, b, and c are all X-linked. In the following cross, you do not know the gene order of these three genes on the chromosome, and you do not know which alleles are on which chromosome of the female parent.

♀ a/+, b/+, c/+ X ♂ X/Y wild type male

You analyze male progeny and obtain the following numbers of flies of each phenotype:

2278	+	+	c
2157	a	b	+
1203	a	b	c
1092	+	+	+
49	+	b	c
41	a	+	+
2	+	b	+
1	a	+	c

a) What are the genotypes of the two maternal X chromosomes?

b) Construct a map showing the order of these three genes and the distances between them. SHOW YOUR WORK

c) Using the data above, prove whether or not there is interference in this region of the X chromosome.

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Question 5 (6 points. There are two parts a,b,c)

5a) The cross (a b c) x (+ + +) is made in the yeast S. cerevisiae, which has unordered tetrads. From an analysis of 200 tetrads, determine the linkage relationships between these three loci. SHOW YOUR WORK.

Tetrad class	1	2	3	4
	abc	ab+	a+c	a++
	abc	ab+	++c	+++
	+++	++c	ab+	abc
	+++	++c	+b+	+bc
number:	80	84	20	16

5b) Diagram a meiosis including any necessary crossover(s) that would produce a tetratype for two unlinked genes d and e:

5c) Diagram a meiosis including any necessary crossover(s) that would produce a tetratype for two linked genes f and g:

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Question 6 (2 points. Two parts a,b)

The X-linked recessive mutation w causes white eyes in Drosophila. You take female Drosophila from a pure breeding line with white eyes and cross them to wild type males (with red eyes).

Parents: X^wX^w x X^+Y

In the F1 you obtain mostly red-eyed females and white-eyed males, but you obtain very rarely a white-eyed male or a red-eyed female.

a) What are the genotypes of the two gametes that combine to form rare white-eyed males?

Gamete from mother: gamete from father:

b) What are the genotypes of the two gametes that combine to form rare red-eyed females?

Gamete from mother: gamete from father:

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Question 7 (5 points. Two parts a,b)

From the complementation data in the table below, assign the ten mutations a1 through a10 to complementation groups. Use the complementation groups to deduce the expected results of the complementation tests indicated as missing data (question marks in chart):

	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10
a1	-									
a2	+	-								
a3	+	+	-							
a4	+	?	+	-						
a5	-	+	+	+	-					
a6	+	+	-	+	+	-				
a7	+	+	?	?	+	-	-			
a8	+	-	+	-	+	+	+	-		
a9	?	?	+	+	-	+	+	+	-	
a10	+	+	+	+	+	+	+	+	+	-
WT	+	+	+	+	+	+	+	+	+	+

a) Complementation groups:

b) Missing data (state + or -)

a4 x a2:

a7 x a3:

a7 x a4:

a9 x a1:

a9 x a2:

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Question 8 (4 points. Two parts a,b)

A culture of bacteria is grown from a single phage-sensitive bacterium. When a sample of the culture is plated onto agar plates that contain phage, almost all cells are killed by the phage, but a few survive and grow up into colonies. The survivors have a new mutation making them phage resistant. Luria and Delbruck did an experiment to find out if these mutations occurred by chance in the liquid culture at some time previous to the exposure to the phage.

a) Below is reproduced some of their data from 4 different repeats of their experiment. In each experiment they grew up 8 small cultures starting from phage-sensitive bacteria, plated each separate culture onto plates containing phage, and analyzed the number of phage resistant colonies.

Number of Phage Resistant Colonies

Culture No.	A	B	C	D
1	10	29	30	6
2	18	41	10	5
3	125	17	40	10
4	10	20	45	8
5	14	31	183	24
6	27	30	12	13
7	3	7	173	165
8	17	17	23	15

For each experiment (A,B,C,D) circle the data point of the culture that was most informative in supporting their conclusion that the mutations occurred by chance before the cultures were plated onto the phage plates.

b) If a spontaneous mutation had occurred in the culture and then another 7 generations of cell division occurred before the culture was plated, how many colonies would arise due to this one mutation?

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Question 9 (6 points. Three parts a,b,c)

Cystic Fibrosis is caused by a recessive autosomal mutation. In the general population, the incidence of cystic fibrosis at birth is approximately one in 1700.

a) A man is known to be a carrier for cystic fibrosis allele. He marries a phenotypically normal woman. Assuming Hardy-Weinberg equilibrium, what is the probability that his wife is also a carrier? SHOW YOUR WORK.

b) What is the probability that their first child will be affected?

c) Although treatment of cystic fibrosis allows many patients to survive to adulthood, assume that affected individuals never have children. What is the rate of new mutations required to explain the stable equilibrium allele frequency? SHOW YOUR WORK.

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Question 10 (10 points. Three parts a,b,c)

Normal bacteriophage T4 produce plaques that are small and rough-edged, and can grow on either *E coli* strain B or K. A stock of T4 phage were grown under mutagenic conditions and plated onto lawns of *E coli* strain B to form plaques. By visual inspection, rare mutants that had large, clear plaques were isolated. This phenotype is called r (for rapid lysis).

a) was this mutant hunt a selection or a screen?

b) Conveniently, r mutants have another phenotype, which is that they can't grow at all on the bacterial strain K. Eight independent mutants with the r phenotype were crossed to one another by co-infection in strain K, to see whether they complemented. The following table shows whether or not plaques formed on strain K for each combination:

	r-1	r-2	r-3	r-4	r-5	r-6	r-7	r-8
r-1	-	-	+	-	+	-	-	+
r-2		-	+	-	+	-	-	+
r-3			-	+	-	+	+	-
r-4				-	+	-	-	+
r-5					-	+	+	-
r-6						-	-	+
r-7							-	+
r-9								-
WT	+	+	+	+	+	+	+	+

What are the complementation groups formed by these mutants?

c) Two mutants that were in the same complementation group did produce very rare recombinants that could grow on strain K. Diagram the genotypes of the two mutant phage and show the crossover event that could yield a wild type phenotype.

d) The two r mutants mentioned in (c) were then tested for their ability to form wild-type recombinants with a set of tester phage that had known deletions. None of the deletion phage could complement the r phenotypes, but some of them could form WT recombinants. In the chart below, the gaps indicate the part of the gene that is deleted in each deletion strain. The + or – in the columns on the right show whether any WT recombinants ever formed between the mutant listed at top and the deletion shown at left (+ means yes, WT recombinants did form).

		Mutant phage: A	B
Del1	----[ ]----------	+	+
Del2	----[ ]----------	-	+
Del3	----[ ]----------	-	-
Del4	---------[ ]----------	-	-
Del5	----------[ ]----------	+	-

On the line shown below the deletions, draw a bracket showing the region in which each of the two mutations must lie. Draw a line up to the deletion endpoint above that defines the boundaries in each case.