1a. (3 pts) You're studying cell cycle control in budding yeast (*S. cerevisae*) and discover a new set of cyclin B mutants. All the new alleles are loss of function mutants. Briefly, describe the phenotype would you observe from the mutant cells. Assume that you have a microscope to see the cells and you can measure their DNA content.

1b. (4 pts) What is the nature of these loss-of-function mutants? You characterize several of the mutants with regard to cyclin B gene expression. You use a cDNA probe to detect the amount of mRNA and gel electrophoresis to detect the amount of protein of the correct size (*see table below*). Based on the observations below, predict the type of mutation in the cyclin B gene.

mutant:	**mRNA amount:**	**protein amount:**	**cyclin mutation?** (nonsense, missense, or frameshift)
mut #1	normal	absent	
mut #2	normal	normal	

1c. (5 pts) In the two mutants above you also identify a mutation in a second gene that acts as a 'suppressor' , that is it restores normal function even in the presence of cyclin B mutations. The 'suppressor' genes are different in the two strains and are not cyclin genes in either case.

Choose one of the mutations above, identify the likely suppressor gene and briefly explain how the mutation in that gene can result in suppression of the cyclin loss-of-function phenotype. Clearly indicate the nature of the mutation in the 'suppressor' gene.

Cyclin mutant #_____ Identity of 'suppressor' gene: _____

Mechanism of suppression *(words or a clearly labeled diagram)*:

2. (6 pts) Although prokaryotes and eukaroyotes share a common ancestor, these two main groups have subsequently evolved special features that distinguish them. List (using just a few words) one major benefit, or advantage, to the organism and one significant cost, or disadvantage, for the following features:

Circular chromosomes in prokaryotes:

benefit / advantage:_____

cost / disadvantage:_____

Nuclear envelope in eukaryotes:

benefit / advantage:_____

cost / disadvantage:_____

3. (7 pts) The molecular processes we have studied typically involve the assembly of complex "machines" involving many macromolecules. Draw a clearly labeled diagram showing the final assembled 'machine' responsible for one of the following. Clearly indicate any relevant proteins, DNA or RNA sequences necessary for the process.

Pick One:

Initiation of transcription of a regulated, highly expressed, eukaryotic, protein-coding gene

or,

Initiation of replication on a prokaryotic chromosome

4. A scientist is interested in the biosynthetic pathway for tryptophan in the fungus, *Aspergillus*. She mutagenizes haploid cells with EMS and isolates 5 strains that require tryptophan. She makes diploids between these mutant strains and records growth without tryptophan as "+" and no growth without tryptophan as "-" in the left hand table. She collects 1000 ascospores from each of these diploids and presents the number of progeny that can grow without tryptophan in the right hand table.

	a	b	c	d	e
a	-	+	+	-	+
b		-	-	+	+
c			-	+	+
d				-	+
e					-

	a	b	c	d	e
a	0	250	250	0	250
b		0	0	250	10
c			0	250	10
d				0	250
e					0

4a. (2 pts) How many genes were identified in this mutagenesis?

4b. (2 pts) Describe the complementation groups identified:

4c. (6 pts) Explain the different numbers of tryptophan-independent progeny in the right-hand table.

4d. (6 pts) Cells from strain "a" were treated with EMS again and plated on minimal medium. 3 prototrophic revertants were obtained and analyzed by crossing to either a wild-type strain or the original "a" mutant strain, with 1000 ascospores from each cross tested for ability to grow without tryptophan.

Strain	Crossed with wild-type strain	Crossed with original "a" strain
1	750	500
2	900	500
3	1000	500

Describe the origin of each prototrophic strain, and explain the numbers of tryptophan-independent progeny from each cross:

1:

2:

3:

4e. (3 pts) Cells from strain "a" were treated with ethidium bromide and plated on minimal medium. No prototrophic colonies were observed. Why not?

5. (3 pts) Huntington's disease is a rare autosomal dominant disorder with late onset, so that many at-risk individuals have families before knowing whether they carry the disease allele. Arlo Guthrie defends his decision to have children by pointing out that he's very glad that his father didn't decide against it (see cover page if you don't know who Arlo Guthrie is). **Ignoring the fact** that Arlo is now 55 and still touring, and so probably does not carry the disease allele, what are the odds that a child of his son, Abe, would be affected by the disease late in life?

6a. (3 pts) For recombination events at the B/b spore color locus in Neurospora, circle all of the spore color ratios that would indicate heteroduplex formation **without repair**:

A. 4B:4b
B. 3B:1b:1B:3b
C. 5B:3b
D.3B:5b
E. 6B:2b
F. 2B:6b

6b. (3 pts) For recombination events at the B/b spore color locus in Neurospora, circle all of the spore color ratios that would indicate heteroduplex formation **with** repair, using the **invading** strand as template:

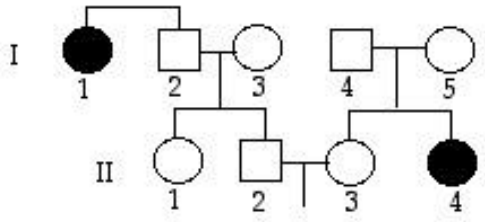
A. 4B:4b
B. 3B:1b:1B:3b
C. 5B:3b
D.3B:5b
E. 6B:2b
F. 2B:6b

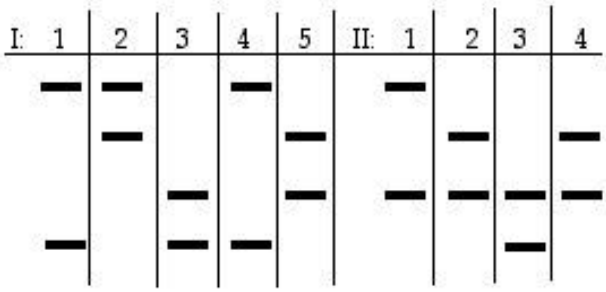
7. (3 pts) Colorblindness is an X-linked recessive disorder. The colorblindness tests that you see in an optometrist's office were developed with the help of a woman who was colorblind in one eye and had normal vision in the other. Explain how this situation could arise.

8. (3 pts) Balancer chromosomes in Drosophila and pressure-induced egg activation in zebrafish represent two very different solutions to a shared problem in eukaryotic mutagenesis experiments. What problem are they designed to overcome?

9. (3 pts) Seedless grapes are autotetraploid. Why do they sometimes have a seed or two, while triploid bananas never do?

10. (6 pts) A man whose father's younger sister had cystic fibrosis marries a woman whose sister had cystic fibrosis. This couple, represented by II-2 and II-3 in the pedigree, are concerned about the possibility of having a child affected by cystic fibrosis. All the individuals shown in the pedigree have been tested for a microsatellite marker closely linked to the cystic fibrosis locus, and the results are shown below the pedigree.





What advice would you give the couple and why?

11. Your friend gives you tomato seeds from the pure-breeding, self-fertilizing tomatoes he has been growing in the community vegetable garden, which is located on the town's former landfill site. When you plant them in your garden, you notice that one plant produces "supersize" tomatoes and another produces tiny tomatoes. Still another plant produces golden-colored tomatoes and has lovely pale blue leaves. After you advise town officials to close down the garden and call your friend to tell him not to eat any more of his produce, you set up the following experiments:

11a. (2 pts) You cross the "supersize" plant and the "tiny tomatoes" plant each with a regular plant, and all the offspring produce normal-sized tomatoes. You self-cross these offspring and see a 3:1 ratio of normal:mutant-sized tomatoes for each. What can you conclude about the "supersize" and the "tiny tomatoes" phenotypes?

11b. (3 pts) You also cross the "supersize" plant with a "tiny tomatoes" plant. All of the offspring produce normal-sized tomatoes, and when these are self-crossed, you observe the following phenotypic ratio:
18 plants with normal-sized tomatoes: 6 plants with "supersize" tomatoes: 8 plants with tiny tomatoes (you have a very large backyard). How do you explain these results?

11c. (6 pts) You cross the "supersize" tomato plant with the golden tomato, light blue leaf plant. All of the F1 offspring look completely normal, with normal-sized red fruit and green leaves. When you self-cross some of these F1 offspring, you find a few plants that show all three traits. You cross these plants back to some of the F1 plants and observe the following offspring:

36	supersize
38	golden, blue
10	supersize, golden, blue
9	completely normal
2	supersize, golden
2	blue
1	supersize, blue
0	golden
100	total

What can you conclude about the relative position of the genes responsible for these traits? Explain your conclusions and show your work.

11d. (3 pts) Is there any evidence of interference in this part of the tomato genome? Explain your conclusions and show your work.

11e. (3 pts) In the first cross, where you generated the triply homozygous plant by self-crossing the F1 plants, what proportion of the offspring would be expected to show all three traits?

11f. (3 pts) You have retired comfortably on the proceeds from patenting your supersized golden tomatoes, thanks to McDonald's new "Golden Arches Health Food Store™" ad campaign, and you can now devote yourself to tomato-breeding full-time. You cross a supersize tomato plant to a normal-looking plant grown from one of the landfill seeds and find that 260 plants produce normal-sized tomatoes and 60 produce supersized tomatoes. Using the chi square test, determine whether these numbers deviate significantly from the expected monohybrid ratio. (Note: you do not need a calculator if you write out the appropriate chi square equation and solve the easily divisible part of it). **Chi square equation and table are on the cover page.**

12. You are intrigued by the light blue leaf phenotype and go back to the now-abandoned community garden before the Environmental Protection Agency begins its soil clean-up. There you find a dark blue-leafed tomato plant. When you cross it to a normal plant, all the offspring are normal, but when you cross it to the light blue-leafed strain, all the offspring have medium blue leaves.

12a. (3 pts) Circle all of the terms that can be used to describe these observations:

A. an allelic series
B. epistasis
C. conjugation
D. incomplete dominance
E. molecular co-dominance
F. suppression
G. failure to complement
H. radiation hybrids

12b. (3 pts) You notice that the medium blue leaves actually have some tiny speckles of normal green pigmentation. Neither of the parental strains have speckles on their leaves. What is the most likely explanation for the speckles you observe in the cross?

12c. (6 pts) You self-cross the speckled medium blue-leaved plants and see the following phenotypic ratios in the offspring:

4/16	unspeckled light blue
6/16	speckled medium blue
2/16	unspeckled medium blue
3/16	speckled dark blue
1/16	unspeckled dark blue

Propose a plausible hypothesis to explain these observations and write the genotypes of each phenotypic class above, using clearly defined symbols.

Cheating is not in my genes – so I didn't! Signed _____