3F05

BIOL 2500 FALL 2005

GENETICS

EXAMINATION 3

Prof Finger

NAME [redacted]

RIN # [redacted]

THIS PAGE IS RESERVED FOR GRADING.
YOU MAY USE THE REVERSE SIDE OF EACH PAGE AS SCRATCH PAPER. THERE ARE 7 QUESTIONS AND 3 BONUS QUESTIONS.

Question 1 12 (max 12)

Question 2 8 (max 10)

Question 3 21 (max 28)

Question 4 18 (max 18)

Question 5 5 (max 8)

Question 6 5 (max 10)

Question 7 4 (max 14)

Bonus 3 (max 3 bonus)

TOTAL: 76

Name: Emily Germain

Question 1 (12 points).

In a bacterial operon, regions *a*, *b*, *c*, and *d* represent the repressor gene, the promoter sequence, the operator region, and the structural gene encoding an enzyme, but not necessarily in that order. This operon regulates the metabolism of a molecule (m). From the data given below, assign *a*, *b*, *c*, and *d* to the four parts of the operon.

Genotype	**m present**	**m absent**
$a^+ b^+ c^+ d^+$	active enzyme	no enzyme
$a^- b^+ c^+ d^+$	active enzyme	active enzyme
$a^+ b^- c^+ d^+$	no enzyme	no enzyme
$a^+ b^+ c^- d^+$	inactive enzyme	no enzyme
$a^+ b^+ c^+ d$	active enzyme	active enzyme
$a b^+ c^+ d^+ / F' a^+ b^+ c^+ d^+$	active enzyme	active enzyme
$a^+ b c^+ d^+ / F' a^+ b^+ c^+ d^+$	active enzyme	no enzyme
$a^+ b^+ c^- d^+ / F' a^+ b^+ c^+ d^+$	active enzyme + inactive enzyme	no enzyme
$a^+ b^+ c^+ d / F' a^+ b^+ c^+ d^+$	active enzyme	no enzyme

d is the repressor gene.

b is the promoter sequence.

a is the operator region.

c is the structural gene encoding an enzyme.

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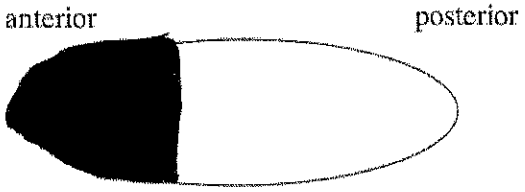
Question 2 (10 points).

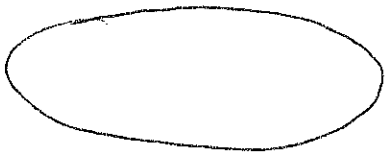
The *Drosophila* gene *bicoid* exemplifies a maternal-effect gene that, when mutated produces embryos that lack anterior structures, but have posterior structures duplicated. The Bicoid protein is a morphogen that establishes the domain of expression of the gap gene *hunchback* by activating *hunchback* transcription in a concentration-dependent manner. The Bicoid protein is usually present in an anterior-to-posterior gradient with the highest concentration at the anterior end of the early embryo. Diagrammed below is the major domain of expression of *hunchback* in an embryo from a wildtype mother.



What are the expected domains of *hunchback* expression in embryos from mothers with the following genotypes. Draw diagrams similar to the one shown here, and predict the phenotype of each embryo.

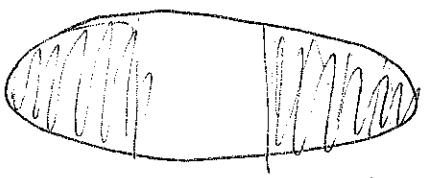
a. Homozygous for a *bicoid* null mutation.
b. Homozygous for a transgene that causes *bicoid* to be localized at both poles of the embryo.

a.



2 posterior ends

b.



2 anterior ends

Name: Emily Germain

Question 3 (28 points).

Classify each of the following mutations based on the information given (more than one term may be necessary):

a. A *C. elegans* cell that normally undergoes programmed cell death develops into an extra neuron. cell lineage mutation ~~homeotic mutation~~ 4

b. Yeast cells that grow normally at 25°C are unable to divide when shifted to 37°C.

temperature-sensitive mutation 4

c. *Drosophila* have legs at the normal site of antennae.

cell lineage mutation
homeotic mutation 4

d. Homozygous *Drosophila* females are normal but produce larvae that have a head at each end and no distal ends. Homozygous males produce normal offspring, assuming that the mate is not a homozygous female. imprinted paternally 3

~~pair wise mutation~~ homeotic
cell lineage mutation

e. The most anterior and posterior regions of the *Drosophila* embryo are eliminated.

~~cell lineage mutation~~ terminal mutation
pairwise mutation
coordinate gene

f. A ACC TGG codon is converted to a CGG codon. GCC in mRNA

base substitution mutation missense or transition 4

amino acid change in protein

g. A *Drosophila* gene normally expressed in the eye is expressed in the leg, causing eye structures to develop on the leg.

~~homeotic mutation~~ 2

*gain of function
cell lineage
partial credit for homeotic

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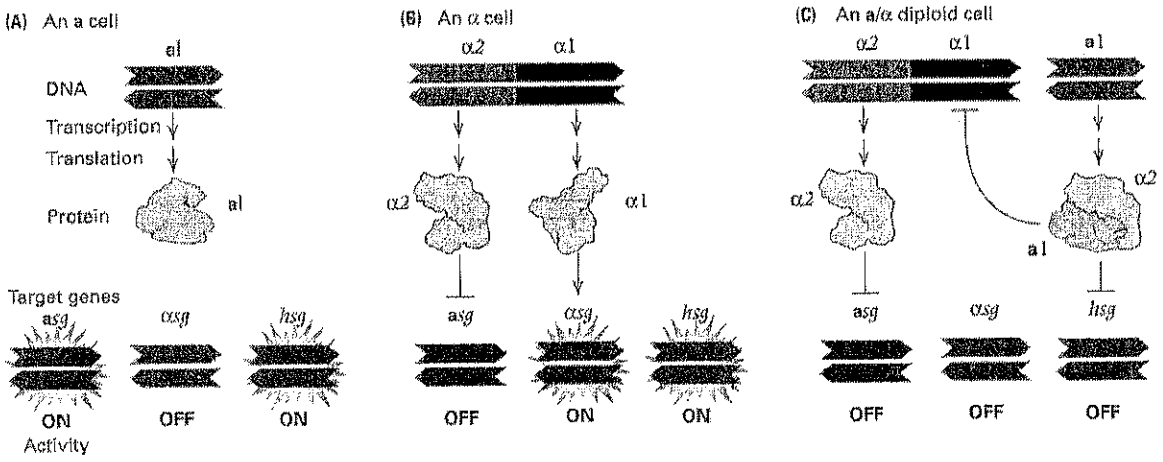
Question 4 (18 points).

A geneticist decides to use yeast DNA microarrays to study effects on transcription of strains of different mating types and deletion mutants in the MAT mating-type locus. To perform these experiments, RNA is extracted from two strains of yeast to be compared, and labeled cDNA probes are prepared from each strain by reverse transcription of the RNA in the presence of either green or red fluorescent labels. The differently labeled cDNA solutions are mixed and applied to a microarray with spots for each of the types of genes shown in the table. *MATα1*, *MATα2*, and *MATa1* are DNAs for the possible coding sequences present at the MAT locus, *α*sg and ***a****sg* spots contain DNA for genes expressed specifically in *α* and **a** cells, respectively, and *hsg* spots contain DNA of genes expressed in haploid cells. The figure of transcriptional regulation of mating type given below is provided for your reference. The symbol Δ indicates a deletion.

For each of the hybridizations in the table, indicate the expected color of the hybridizations (red, green, yellow or none). Yellow indicates equal amounts of both fluorescent labels, none indicates lack of expression in both strains.

Red	Wildtype ***a*** cells	Δ *MATα1* cells	Δ*MAT*(α1 α2)/Δ*MATa1* ← makes none of these proteins
Green	Wildtype **a**/*α* cells	Wildtype *α* cells	Wildtype ***a*** cells
MATα1	None	Green	None
MATα2	Green	Yellow	None
MATa1	Yellow	None	Green
*α*sg	None	Green	None
a*sg*	Red	None	Yellow
hsg	Red	Yellow	Yellow



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Question 5 (8 points).

For each situation, write the term for the mechanism of gene regulation described:

a. V-J joining of antibody genes.

2 ~~gene~~ somatic recomination programmed DNA rearrangement

b. Polycomb group proteins bind to a DNA sequence preventing transcription.

3 repression transcriptional silencing

Question 6 (10 points)
The human genome has about 300,000 copies of a transposon-like repetitive element known as an *Alu* repeat. These elements have recently been shown to be the source of genetic disease. Describe two mechanisms by which *Alu* elements could cause disease.

5 An Alu element could transpose into the middle of ~~a~~ a necessary gene and disrupt production of its protein. The gene could be split or excised out during transposition. If it transposes into an intron it could make the gene too long ~~for~~ for RNA polymeras~~e~~ to stay on over the length of it so transcription doesn't finish often ~~enough~~ enough.

inserts in gene and disrupts

ectopic recombination

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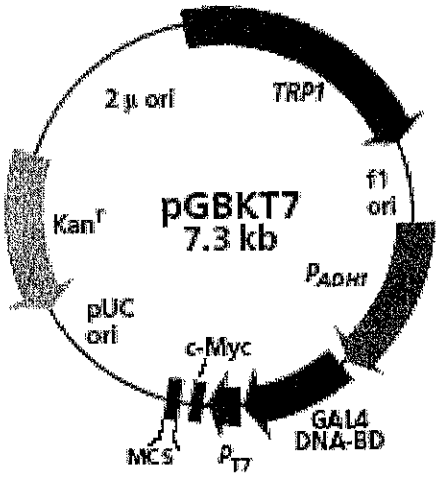
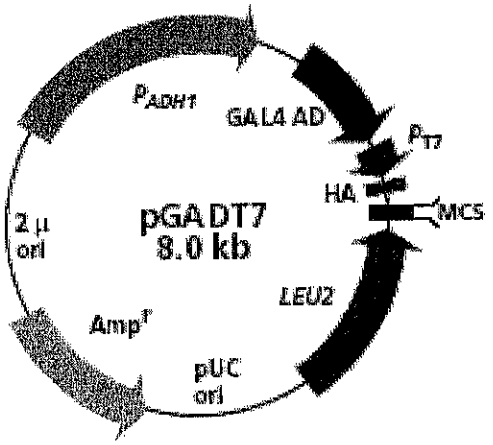
Question 7 (14 points). Refer to the plasmid maps to answer the questions below.





origin of replication for two species to be replicated and selected for in two species

a. What features of the plasmid pGADT7 enable it to function as a shuttle vector?

1 can be selected with antibiotics
has enzyme splice site for restriction enzymes to come in and splice in a selected sequence. The ~~bacteria~~ MCS site has numerous different restriction enzyme splice sites

b. How is the *GAL4* transcriptional activator used in the pGBKT7 and pGADT7 plasmids to facilitate the discovery of interactors with a protein of interest?

7 If the ~~dna~~ of ~~interest~~ is properly spliced in in the correct orientation, production of ~~the~~ GAL4 protein can be induced.

the protein of interest can be attached to the protein product of GAL4. Other proteins can be attached to another protein that binds the DNA in this region. If the two proteins in question interact, the DNA will be bent in such a way as to allow access to the promoter region and the ~~GAL4~~ proteins regulated by GAL4 will be produced.

7 used for two-hybrid screen, GAL4 separated into two domains and need to insert interest protein to screen a library

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Bonus questions (1 point each).

Explain in 1-2 sentences, using only the space provided, the significant contributions of each geneticist(s).

1. John Sulston [redacted] mapped the lineages of cell differentation in C. elegans

2. Eric Wieschaus and Christiane Nusslein-Volhard
   discovered genes important for determining body segments in fruit flies.

3. Joshua Lederberg
   designed the method of replica plating so copies of plates can be made and different things selected for, mapping the original plate

Optional: Check one answer for each question.

This test was _____ too short _____ too long ___X___ about right.

This test was _____ too easy ___X___ too hard _____ about right.

Second Position

First Position (5′ end)	U		C		A		G		Third Position (3′ end)
U	UUU, UUC	Phe	UCU, UCC, UCA, UCG	Ser	UAU, UAC	Tyr	UGU, UGC	Cys	U
	UUA, UUG	Leu			UAA	Stop	UGA	Stop	C
					UAG	Stop	UGG	Trp	A
									G
C	CUU, CUC, CUA, CUG	Leu	CCU, CCC, CCA, CCG	Pro	CAU, CAC	His	CGU, CGC, CGA, CGG	Arg	U
					CAA, CAG	Gln			C
									A
									G
A	AUU, AUC, AUA	Ile	ACU, ACC, ACA, ACG	Thr	AAU, AAC	Asn	AGU, AGC	Ser	U
	AUG	Met			AAA, AAG	Lys	AGA, AGG	Arg	C
									A
									G
G	GUU, GUC, GUA, GUG	Val	GCU, GCC, GCA, GCG	Ala	GAU, GAC	Asp	GGU, GGC, GGA, GGG	Gly	U
					GAA, GAG	Glu			C
									A
									G