7.014 Quiz III

4/22/05

Your Name: _____ **TA's Name:**_____

Write your name on this page and your initials on all the other pages in the space provided.

This exam has 10 pages including this coversheet. Check that you have pages 1-10.

This exam has 4 questions. Read all questions before starting to write.

Write your answers as clearly and precisely as possible in the space provided.

This is a closed book exam.

Question	Value	Score
1	20	_____
2	22	_____
3	30	_____
4	28	_____
TOTAL:	100	_____

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Question 1 (20 points)

The table below lists types of metabolism in the left column.

Type of metabolism	Electron source	Carbon source	Energy source
fermentation			
sulfur oxidation chemosynthesis			
oxygenic photosynthesis			
anaerobic respiration			
nitrification chemosynthesis			
aerobic respiration			
anoxygenic photosynthesis			

a) For each type of metabolism,
   i) use the following list to fill in Electron source (column 2) and Carbon source (column 3) in the table above.
      A. sugar (Note, "sugar" here is a generic term for any organic carbon compound $(CH_2O)_n$).
      B. Water (H_2O)
      C. hydrogen sulfide (H_2S)
      D. methane (CH_4)
      E. carbon dioxide (CO_2)
      F. NH_3

   ii) fill in Energy source (column 4) in the table above. For this part, you are not limited to the list above.

b) For a number of the metabolisms above, the electron source is the same as the energy source. Explain why they are not the same for photosynthesis.

c) Organisms carrying out respiration need a final electron donor / acceptor to keep the electron transport chain (ETC) functional. (Circle the correct term above.)

Explain how this compound enables the ETC to remain functional.

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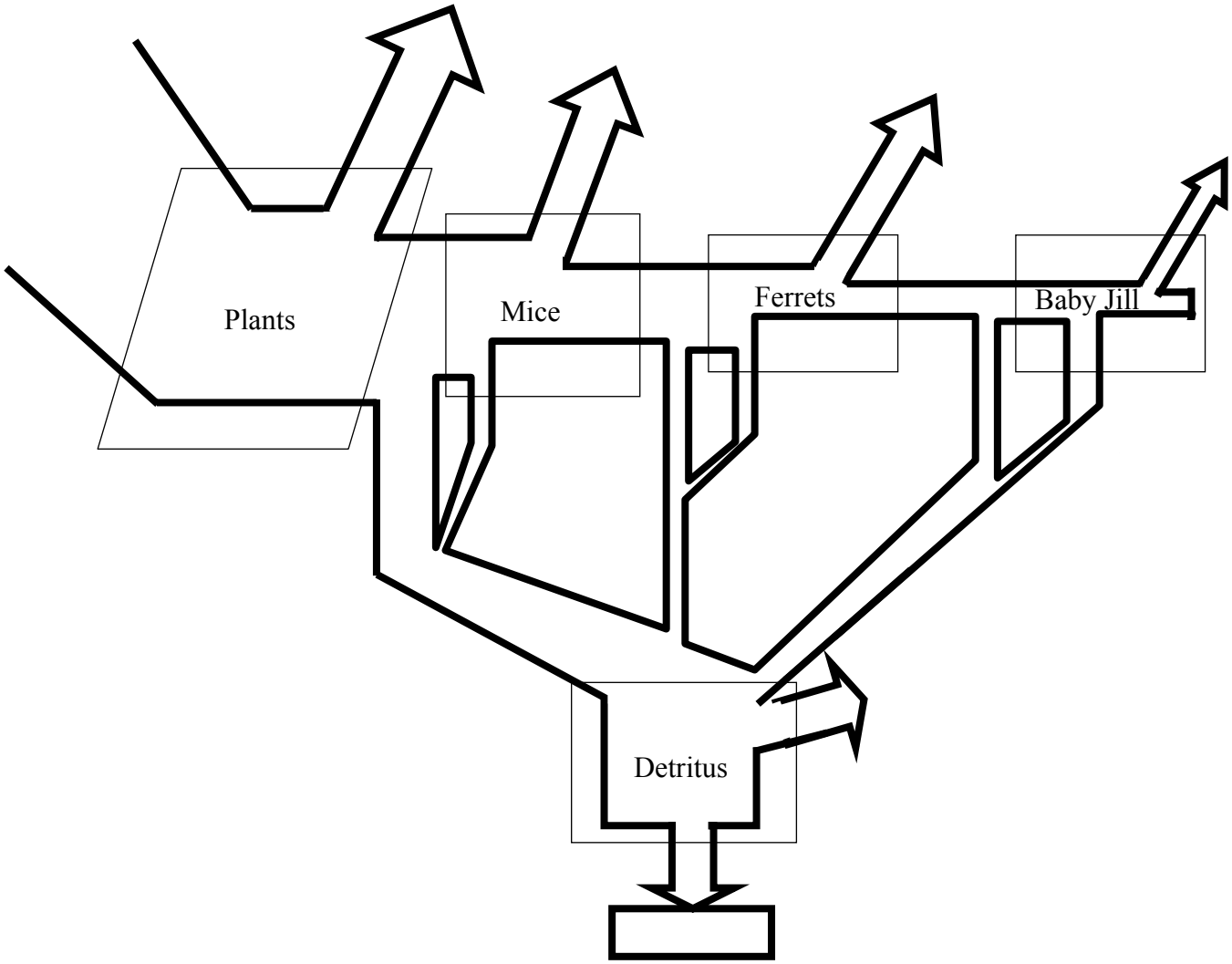
Question 1, continued

d) Using an argument based on redox and energetics, explain how aerobic respiration generates more ATP per molecule of glucose than anaerobic respiration.

Question 2 (22 points)

Baby Jill is stuck on an uninhabited island. The food web quickly comes to look like this:



In this web,

NPP (plants)=200 kg/day
I_M (Mice ingestion) = 20kg/day
Mice AE (assimilation efficiency) = 20%
Mice PE (production efficiency) =10%
Ferret EE (exploitation efficiency) = 50%
Ferret AE = 80%
Ferret PE = 10%
Baby Jill EE = 40%
Baby Jill AE = 80%
Baby Jill PE =10%

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Question 2, continued

a) Suppose that shortly after baby Jill's arrival the flow into the refractory carbon pool in the system decreased. Why was there a decrease?

b) How many grams/day of carbon are stored in the form of ferrets? Show your work.

c) Given only the information on the previous page, is it possible to calculate the mean residence time of carbon in the ferret trophic level? Why or why not?

Suppose baby Jill gave ferrets a drug that lets them increase biomass faster on the same amount of food.

d) What system parameter(s) could have changed as a result? (circle all that apply)

NPP PE_J AE_J GPP EE_F PE_F AE_F

Why?

Baby Jill finds some squash seeds and plants them on a previously vegetation-free lot. She is tired of eating ferrets, so she plans to eat squash exclusively when it is ready. Note that Jill is the only one on the island who will get to eat squash.

e) In the table below, for each system parameter listed, circle Yes or No to indicate whether that parameter will change once Jill plants and begins eating squash. For ONLY the parameters you believe will change, explain why in the space provided.

Parameter	Change?	Justify
NPP	Yes No	
EE_J	Yes No	
PE_J	Yes No	
AE_J	Yes No	
GPP	Yes No	
EE_F	Yes No	
AE_F	Yes No	
EE_M	Yes No	
AE_M	Yes No	

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Question 3 (30 points)

You hope to use your hard-won 7.014 knowledge to make some extra cash over the summer, so you adopt two Chinchillas to start a Chinchilla breeding business.

Your Chinchillas are Standard male and a rare Velvet female. Chinchillas with Velvet coats have especially thick, soft hair.

Your first hypothesis is that the Velvet (coat thickness) is an autosomal trait.

a) Draw and label a diagram of a Chinchilla cell right before the first meiotic division. Pretend for the moment that chinchillas only have two pairs of chromosomes both of which are autosomal. Your cell should be heterozygous at the Velvet locus. Make sure to label each allele, using A to indicate the dominant allele and a to indicate the recessive allele.

You reason that the rare Velvet coat phenotype of your female is recessive to the Standard coat phenotype of your male. Your male comes from a long line of show quality Standards, so you feel safe assuming that he is homozygous at the Velvet locus.

b) You cross you Standard male and Velvet female. If your assumptions are correct, what coat phenotypes would you expect to see in the
   i. F1 generation?

   ii. F2 generation?

In your F1 offspring you find chinchillas of both sexes with Standard coats and a lot of males with Velvet coats. Your buddy from 7.014 suggests that, in contrast to your previous hypothesis, the Velvet phenotype is recessive and sex-linked. Chinchilla sex chromosomes are named X and Y and behave like human sex chromosomes.

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Question 3, continued

c) Suppose that your buddy is right and the Velvet gene is on the X chromosome. For the parental cross below, fill in the parental genotypes of your Velvet female and Standard male. Use X^A and X^a notation.
In the F1, fill in genotypes and phenotypes of the expected offspring.

♀_____ X _____ ♂

↓

F1:

Among the F1 progeny, you find a lone Velvet female.

d) Is the recessive sex-linked inheritance pattern still possible given this data? Why or why not?

You confirm with the use of internet that only one autosomal gene is involved in the Velvet coat phenotype. Your friend now suggests two more hypotheses consistent with this fact:

(1) your Standard is actually heterozygous at the velvet locus (Aa), while your Velvet is homozygous (aa).
(2) your Velvet is actually heterozygous (Aa), and your Standard is homozygous (AA).

Recall that the parental cross (Standard X Velvet) gave a mix of Standard and Velvet coats.
To determine which hypothesis above is correct, you do the following two crosses and get the following results:

Cross 1: F1 Standard X P Standard

↓

Offspring: All Standard

Cross 2: F1 Velvet X P Velvet

↓

Offspring: Velvet and Standard

e) These results support hypothesis number ____
Explain your choice.

Question 3, continued

f) After repeating cross 2 a number of times, the overall ratio of progeny is 1 Standard to 2 Velvet. Explain this result.

Since Standard coat animals do not sell for as much as Velvet animals, you buy several females with Brown Velvet coats to mate with your Grey Velvet males. Brown is dominant over Grey. However, you are not sure whether the Brown Velvet females you bought are pure breeding at the coat color locus.

You know that two unlinked genes are involved with these phenotypes— one for coat color (B/b), and one for Velvet coat thickness (A/a). After a few years of mating the original pairs, you find they have produced the following offspring:

10 Standard Grey
28 Grey Velvet
13 Standard Brown
24 Brown Velvet

g) For the parental cross above, fill in the parental genotypes at the coat color and coat thickness loci of your Brown Velvet females and your Grey Velvet males.

♀_____ X _____ ♂

h) Give the phenotype for each of the possible F1 genotypes below:

BbAA

bbAA

BbAa

bbAa

Bbaa

bbaa

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Question 4 (28 points)

You are studying a small experimental plant known as *Cactusus experimentalis*.

You would like to create a genomic library of *Cactusus experimentalis* so you can find the gene responsible for touch sensitivity, called TOU.

a) List the three features your cloning vector must contain to be useful in construction of a genomic library.

1.

2.

3.

b) After isolating the genomic DNA, what enzymes and reagents would you need to buy for the remaining steps of constructing a genomic library? (Circle ALL that apply.)

Enzymes	Reagents
DNA Polymerase	dATP, dCTP, dGTP, dTTP
RNA Polymerase	ddATP, ddCTP, ddGTP, ddTTP
Ligase	Primers
Restriction enzyme	*E. Coli*
Reverse Transcriptase	Human Cells
	Cloning Vector
	DNA template
	ATP, CTP, GTP, TTP

You create the genomic library (starting with an EcoRI digesting of the DNA), and identify one vector that contains your TOU gene. You decide to analyze this vector further. You cut the vector with EcoRI and purify the genomic insert. You then digest the insert with 2 different restriction enzymes SpaII and HindIII. You obtain the following results:

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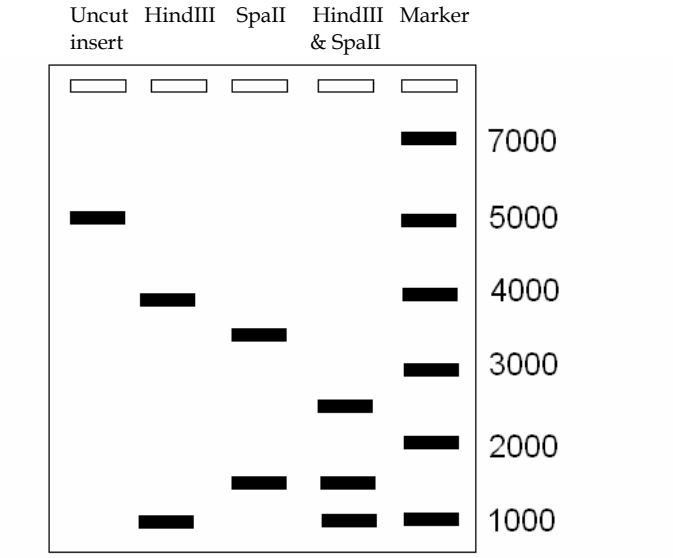
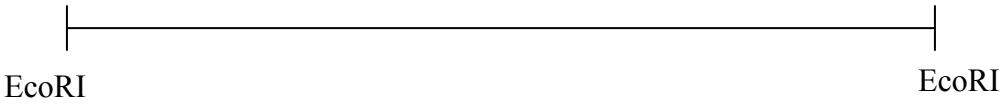
Question 4, continued



c) Draw a map of the genomic insert indicating restriction sites for the enzymes SpaII and HindIII. EcoRI sites are already shown for you. Be sure to include distances.



You then decide to sequence a small portion of the TOU gene found on your insert.

d) Circle ALL the enzymes and reagents on the following list that you would need to perform a sequencing experiment.

Enzymes	Reagents
DNA Polymerase	dATP, dCTP, dGTP, dTTP
RNA Polymerase	ddATP, ddCTP, ddGTP, ddTTP
Ligase	Primers
Restriction enzyme	*E. Coli*
Reverse Transcriptase	Human Cells
	TOU gene insert
	ATP, CTP, GTP, TTP

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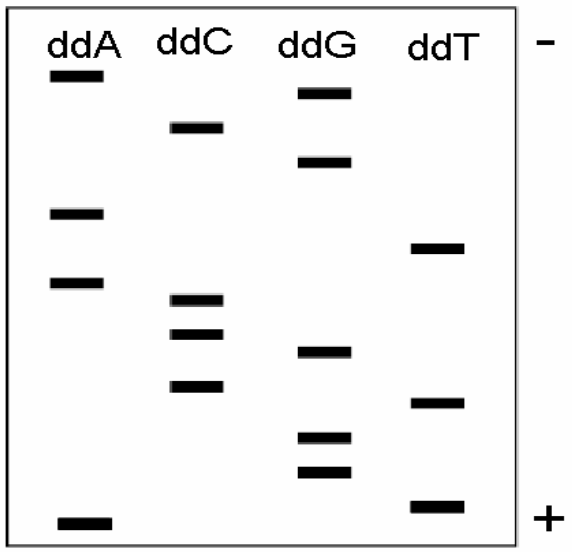
Question 4, continued

You obtain the following gel after amplification.



e) What is the sequence represented on the gel? Be sure to indicate the 5′ and 3′ ends.

f) After sequencing the TOU gene obtained from your genomic library you find a 32 base pair insert in the middle of it that does not correspond to the mRNA for TOU. What is it?

g) You want to express the TOU gene in *E. coli*.
   i. Given the result in part f, would you want to use genomic or cDNA library for this experiment? Why?

   ii. What organism must the promoter be from? Why?