

1. (4 points) You are doctor at a North Carolina HMO. Your first patient of the day is a 23 year old man who presents with nausea, confusion and, most notably, signs of flaccid paralysis. Yesterday he had eaten canned tuna in a salad made with homemade mayonnaise.

What illness does he have and what is the agent?

How does this agent's virulence factor work?

How would you treat this patient?

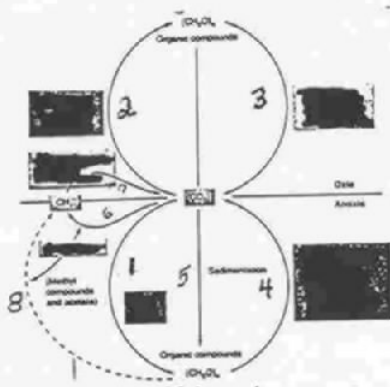
2. (4 points) Complete the following table:

Disease	Agent	Reservoir	Host	Vector
Lyme Disease	<i>B. burgdorferi</i>	mammals	humans	
Plague	<i>Y. pestis</i>		humans	flea
Yellow Fever	Y.F. virus	primates		mosquito
Tetanus	<i>C. tetani</i>		humans	fomites

14. (10 points) You are interested in studying the mechanisms of gene regulation in a bacterium which is a facultative anaerobe (that is it can grow both aerobically and anaerobically). You discover that there are a number of proteins whose genes are located in different operons which are expressed only when the bacterium grows anaerobically. You isolate some transposon mutants resulting from a single insertion of the transposon which affect the expression of many of these proteins from different operons at the same time. The transposon mutants seem to fall into 2 groups so that you believe that you have 2 types of global regulatory mutants. In order to focus your studies of these mutants you draw up the following table of the properties you expect of different types of mutants. You may choose any two **different** types of global regulatory mutations to use to fill in the table but **be clear about the type** of mutant you are describing.

type of global regulatory mutant		
if you sequence the mutated gene, name one gene you would expect to turn up in a homology search using your sequenced regulatory gene		
predicted cellular location of the gene product		
predicted enzymatic activity, if any		
substances to which the gene product might bind, if any		

3. (10 points) Below is a diagram of the carbon cycle for your text:



Name a **type** of prokaryote which carries out reaction 1 _____

Name a **type** of prokaryote which carries out reaction 2 _____

Are there any eukaryotes which carry out reaction 1? _____

Which reactions can be carried out by archaeobacteria? _____

Which reactions can not be carried out by archaeobacteria? _____

If organisms which can carry out reaction 2 had never evolved, what would be the major consequence? _____

In a microbial mat, which reaction(s) of the above diagram is/are found primarily in the top layer? _____

Which groups of organisms have photosystem I? _____

Which groups of organisms have photosystem II? _____

From which type of photosystem do you get more ATP and reducing power? _____

4. (6 points) Complete the table below for deep ocean vent and rumen symbioses:

		provides to the other partner	biochemical modification in the animal
V e n t	tube worm		
	bacteria		XXXXXXXXXXXXXXXXXXXXXXXXXXXX
r u m e n	animal		
	bacteria		XXXXXXXXXXXXXXXXXXXXXXXXXXXX

5. (12 points) Complete the following table:

reaction	reduction or oxidation	reason for reaction (that is, why does an organism do this?)	example of organism which carries out this reaction
$\text{NH}_3 \rightarrow \text{NO}_2^-$			
$\text{N}_2 \rightarrow \text{NH}_3$			XXXXXXXXXXXX
$\text{NO}_3^- \rightarrow \text{NO}_2^-$			XXXXXXXXXXXX
$\text{S}^0 \rightarrow \text{SO}_4^{2-}$			
$\text{S}^0 \rightarrow \text{H}_2\text{S}$			XXXXXXXXXXXX

6. (4 points) Recently it has been reported that one of the gene-modified corn cultivars releases insecticide through its roots into the soil. Although this characteristic may be beneficial for farmers, it is important to make sure that the compound is effectively broken down to CO_2 and H_2O . You measure the amount of insecticide in a soil sample you take from a field where this corn was planted, at the time of planting and after few months. To your surprise, you notice that there is only 20% of the insecticide you started with, and more over it is mostly converted to CO_2 and H_2O . You would like to isolate the microorganism(s) which are responsible for this metabolism. Would you expect to find one single microorganism? Yes or No (Circle one) Why?

7. (5 points)

A. It is known that if an microorganism can transform one organic compound into another, it obtains either energy or C from it. True or False (circle one)

B. Which of the following have a large effect the rate of breakdown of a phenyl ring compound? (circle all of the correct answers)

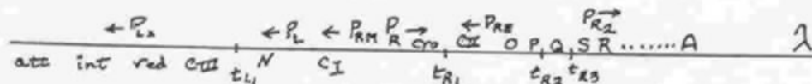
- position of substituents on the ring
- chemical nature of the substituents on the ring
- presence or absence of oxygen
- presence or absence of light
- temperature between 15 and 30° C
- pH between 5 and 8

C. All ecosystems on earth ultimately depend sunlight as the energy source. True or false (circle one).

8. (6 points) Fill in the following table.

Bacterium and medium or growth conditions	substances supplying energy and source, if not in growth medium	original electron donor	final electron acceptor
<i>Rhizobium</i> growing in a nodule			
<i>E. coli</i> growing aerobically with NO_3^- and SO_4^{2-} and glucose			

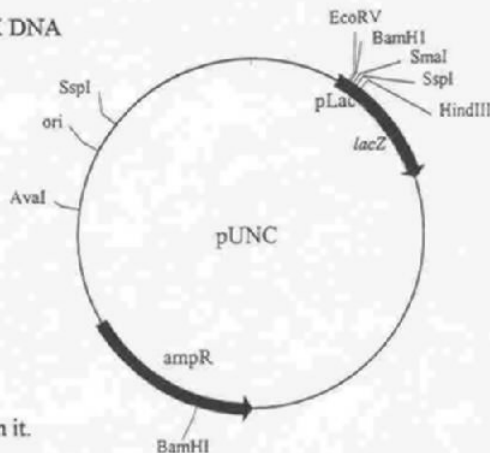
9. (8 points) Fill in the following table with respect to the phenotype of various mutants in phage λ . Plaques can be clear, cloudy, or none. Mutants can cause plaques to become cloudier or clearer than wild type.



λ phage genotype	plaques on <i>E. coli</i> K12 (-)	plaques on <i>E. coli</i> K12 (λ)
<i>CI</i> mutant		
mutant with t_{R1} deleted		
mutant with P_{lac} substituted for P_R with the infection done in medium containing lactose		
mutant with P_{lac} substituted for P_{RE} with the infection done in medium containing lactose		

10. (14 points) You isolate a new nitrogen fixing bacteria from a lima bean plant and want to clone its *nifK* gene. You have the following available (you don't need to use all of them):

recently isolated nitrogen fixing bacteria (r.i.n.f.b.)
wild type *E. coli*
competent *E. coli*
the plasmid shown pUNC
radioactively labeled *Rhizobium leguminosarum nifK* DNA
mice
cats
lima bean plant
soybeans
All enzymes and buffers necessary
kanamycin, ampicillin, chloramphenicol, tetracycline
Xgal
glucose
arabinose
complex medium
minimal medium



Grow _____ and purify _____ from it.

Digest the _____ DNA with _____.

Digest the vector DNA with _____.

Mix the two digests together and add _____ (enzyme). Incubate.

Transform the mixture into _____.

Grow the resultant bacteria and plate them on _____. Keep the _____ colonies. This procedure selects / screens (circle one) for bacteria which contain the plasmid and selects / screens (circle one) for bacteria which contain a vector with inserted DNA.

Transfer candidate colonies on membrane, lyse cells and _____.

Identify those colonies that contain the *nifK* gene by

11. (16 points) Fill in the following table indicating the probable results of the interaction of a alfalfa plant and its *Rhizobium* partner of the indicated genotypes. Indicate whether nodules would be formed, if so their **color/appearance**, and whether N₂ fixation would occur (**yes/no**)

alfalfa genotype	bacterial genotype	Result of the interaction	
		nodules (presence and color)	N ₂ fixation
wild type	wild type		
wild type	<i>nifHDK</i> ⁻		
wild type	<i>nod</i> ⁻		
doesn't make flavonoids	wild type		
legume hemoglobin minus	wild type		
wild type	1 bacterium: alfalfa <i>Rhizobium nifHDK</i> ⁻ <i>nod</i> ⁻		
wild type	2 bacteria: 1. alfalfa <i>Rhizobium nifHDK</i> ⁻ 2. clover <i>Rhizobium nod</i> ⁻		
wild type	2 bacteria: 1. clover <i>Rhizobium nifHDK</i> ⁻ 2. alfalfa <i>Rhizobium nod</i> ⁻		

12. (4 points) You have just isolated a new virus responsible for an outbreak of disease on beans. The virus is an RNA virus with 3 segments. The third segment appears to contain two ORFs: the first for a gene of unknown function and the second for the coat protein. As you study the epidemiology of this virus you find it infecting many other plants in addition to beans. You construct a genetically engineered bean which is resistant to the virus by introducing the gene for the coat protein into a plant chromosome. Then much to your dismay you find other strains of this virus with a completely unrelated coat protein. How could these strains have arisen? What human disease has a similar problem?

13. (5 points) Some bacteria are capable of forming spores. What are the conditions which favor spore formation?

Draw 3 major steps leading to spore formation in *B. subtilis*. Start with cell division and end up with the spore. Indicate the locations of specialized cell wall layers and chromosomal DNA.

What is the major regulatory mechanism used to control the sequence of steps in spore formation?

15. (12 points) Fill in the following table.

Fill in the following table.

characteristic	eubacteria	archaea	eukaryotic nuclei and cytoplasm
presence of histones			
presence of introns or inteins (indicate which, if either)			
presence of operons			
biochemical nature of membranes			