



NOTE: For all short essays on the exam you will be graded on both the content of your answer (most of the points) and on its organization (a few of the points). Please take the time to write out a practice answer using the back side of the paper and then write you answer in the box provided.

1. (4 points) You are a doctor in North Carolina. It is a warm summer day. A young woman; she is experiencing headache, fever and muscle pain. comes to see you. There is a round spot of red rash on her very suntanned leg. She just returned from a hike in the Appalachian Mountain range.

What is her disease likely to be? \_\_\_\_\_

Briefly describe the lifecycle of the pathogen and how it is transmitted?

2. (12 points) A few months later you are in Zimbabwe, participating in the Doctors Without Borders program. Your most recent patient describes his recent symptoms as “litters of diarrhea”. His diarrhea is accompanied by quickened pulse, dry skin, and abdominal cramps. What is this disease likely to be?

\_\_\_\_\_

How would you treat this disease? (be specific) \_\_\_\_\_

What is the agent responsible for this disease, and what tissues does it infect?

\_\_\_\_\_

Describe in detail the mechanism of action of the major virulence factor of this organism.

3. (4 points) Ten years from now you are working for the Center for Disease Control (CDC) in Georgia. There is an outbreak of bloody diarrhea associated with the consumption of chicken. You are asked to look for the causative organism and much to your surprise it appears to be *C. jejuni*. How could this bacterium have acquired the ability to cause bloody diarrhea?

4. (4 points) Why is it that we can use the same immunization for yellow fever for the last 50 years but must change the immunization for influenza every year and substantially over the course of 50 years?

5. (3 points) You tell a friend whose family has an orchard in western North Carolina that freeze injury to the blossoms in the spring is actually a bacterial disease. She wants to know how this can be so. What is your answer?

6. (9 points) Use the word bank below to answer the following questions.

Primary Immunity	Cytokines	Initial Response
Innate Immunity	Macrophages	Secondary Response
Secondary Immunity	Ig1	B cells
Adaptive Immunity	IgE	T cells
Toxins	IgM	Hospital microbes
Beta-blocker	IgA	IgG

If a newborn baby gets a bacterial infection what kind of immunity is at work?  
 \_\_\_\_\_ . Is memory associated with that kind of immunity?  
 \_\_\_\_\_ That same child is now three and gets a viral infection, what kind of immunity is active in her this time? \_\_\_\_\_

A decade later she is in need of a graft transplant, to minimize the chance her body will reject it you must make sure \_\_\_\_\_ type of immunity is suppressed.

What are the two main types of antibodies associated with this kind of immunity, what response are they seen in and which one is faster?

Type of Antibody/ response	Rate of response
1.	
2.	

What is the GENERAL name of the family of cells that can engulf foreign pathogens, process it, and present it to circulating T cells? \_\_\_\_\_

7. (8 points) Your colleague has a problem cloning a toxin gene from *Clostridium difficile* and comes to you for help. He is trying to make a toxoid to use in an experimental immunization. You tell him to explain his protocol and he says he had access to the antibodies for the toxin protein. He digested *C.difficile* DNA with *EcoR*I being careful to do partial digestions and cloned the DNA into a multiple copy vector which he transformed into *E. coli* (the map of the vector is shown above). He tried to identify a clone carrying the toxin gene using the antibodies he had available but was unable to find the clone. He has antibodies available for the cytochrome protein, and he identified this clone with no difficulty. Give 3 possible reasons for his failure to find a clone of the toxin gene and suggest a way to fix (or test) one of them.

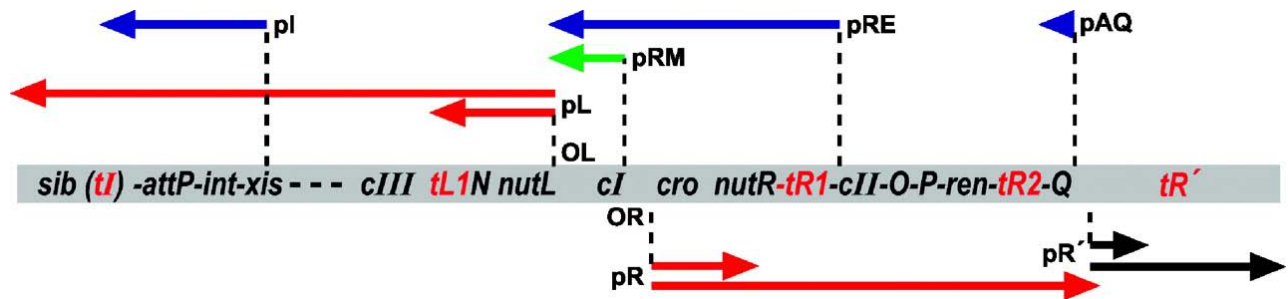
Reasons for failure to obtain clone.

1.
2.
3.

Method for determining if your hypothesis # \_\_\_\_\_ (listed above) is correct.

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8. (8 points) Fill in the following table with respect to plaques caused by  $\lambda$  phage (indicate clear, cloudy, or none) and answer the thought question.



phage genotype	E. coli K12 (-) <i>lacZ</i> <sup>+</sup>	E. coli K12 ( $\lambda$ ) <i>lacZ</i>
wild type $\lambda$		
$\lambda$ CII <sup>-</sup>		
$\lambda$ P <sub>R</sub> replaced by P <sub>lac</sub> all cultures grown on minimal medium with glucose		
$\lambda$ P <sub>R</sub> replaced by P <sub>lac</sub> all cultures grown on minimal medium with glycerol* and lactose		

\* glycerol can serve as a carbon source for *E. coli* but does not participate in the regulation of gene expression by carbon source

Lactose (*lac*0) and galactose (*gal*) are sugars, *trp* is an amino acid, biotin (*bio*) is a vitamin, streptomycin (*Sm*) is an antibiotic.

What will happen if you perform the following conjugation:

*E. coli* K12 ( $\lambda$ ) Hfr *trp*<sup>+</sup>, *bio*<sup>+</sup>, *gal*<sup>+</sup>, *Sm*<sup>S</sup> X *E. coli* K12 (-) *trp*<sup>-</sup>, *bio*<sup>-</sup>, *gal*<sup>-</sup>, *Sm*<sup>R</sup>

And plate on minimal medium with *gal*, *trp*, and *Sm*? Would you obtain transconjugants? Why or why not?

9. (10 points) Cellulose is made by *E. coli* only at 25° C in low ionic strength medium when the culture reaches stationary phase. List three **different** regulatory mechanisms which could be involved in controlling cellulose synthesis.

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

Pick one of them (I chose number \_\_\_\_ ) and describe how it might work.

Just as you are about to test to determine whether the mechanisms you have listed are in fact correct, you see a paper showing that the level of mRNA from the cellulose synthesis operon does not change with growth conditions. Does this fit with any of your proposed mechanisms? YES or NO (circle one).

If yes which one and how? If no, modify one of your mechanisms to accommodate this result or propose another mechanism which would fit.

Note: these questions will be graded as 6 points minus the number of incorrect answers, with no score less than 0.

10. (6 points) Circle all of the compounds below which a bacterium could use as an electron acceptor in anaerobic respiration.

CH <sub>4</sub>	CH <sub>3</sub> OH	NO <sub>2</sub> <sup>-</sup>	NH <sub>3</sub>	H <sub>2</sub> S	SO <sub>4</sub> <sup>-</sup>
benzene	hexachlorobenzene		nylon	cellulose	octane
acetate	Fe <sup>+2</sup>	Fe <sup>+3</sup>	N <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O

11. (6 points) Circle all of the compounds below which a bacterium could use as an energy source.

CH <sub>4</sub>	CH <sub>3</sub> OH	NO <sub>2</sub> <sup>-</sup>	NH <sub>3</sub>	H <sub>2</sub> S	SO <sub>4</sub> <sup>-</sup>
benzene	hexachlorobenzene		nylon	cellulose	octane
acetate	Fe <sup>+2</sup>	Fe <sup>+3</sup>	N <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O

12. (6 points) For this question you have available whatever radioactive compounds you need, means of determining the radioactivity present in various compounds, stains and dyes, fluorescent antibodies as needed, nucleic acids both large and small, all enzymes and buffers to work with these materials and a good microscope.

You are studying a site in a river estuary in eastern North Carolina. You wish to know how much bacterial CO<sub>2</sub> fixation is occurring in the mud at its bottom. You take a sample of the mud. How do you measure the amount of CO<sub>2</sub> fixation actually occurring?

You wish to know how many total prokaryotes are present per gram of soil. What do you do?

You want to estimate how many of these prokaryotes are archaea and how many are eubacteria. How do you do this?

13. (8 points) Hydrothermal vents found on the ocean floor support a wide diversity of prokaryotes and even some multi-cellular animals such as giant clams, tubeworms, etc. Answer following questions based on your knowledge of hydrothermal ecosystems.

What allows large multi-cellular organisms to obtain energy in complete darkness?

\_\_\_\_\_

How are the worms modified anatomically to as a result of the symbiosis? \_\_\_\_\_

How are the worms modified biochemically to accommodate the symbiotic organisms?

\_\_\_\_\_

Cows have symbiotic bacteria in their rumen.

How are the cows modified biochemically as a result of this symbiosis?

\_\_\_\_\_

Legumes have symbiotic bacteria in their roots.

How are the plants modified anatomically to as a result of the symbiosis?

\_\_\_\_\_

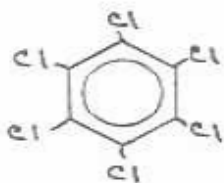
How do the plants attempt to insure that the potential symbiotic bacteria are not in fact some sneaky pathogen?

14. (8 points) A big-time chemical company comes to you and has a problem. It has a waste site which it wants to clean up. It doesn't want to give out too much information. What three things in addition to the general structure of the compound do you NEED TO KNOW to help the company?

- 1.
- 2.
- 3.

If the product is a long chain hydrocarbon, under what conditions would you expect degradation to occur?

If the product is a hexachlorobenzene (see picture below), under what conditions would you expect degradation to occur?



The Science director of the chemical company wants you to isolate the organism that does the degradation and study the kinetics of degradation. Is this a good idea? Why?

15. (9 points) Complete the table below. Describe the environment, biochemical or physical adaptations, and energy source of the following Archaeobacteria.

	<b>Environment</b>	<b>Biochemical or Physical adaptations</b>	<b>Energy Source</b>
<b>Halophiles</b>			
<b>Methanogens</b>			
<b>Extreme Thermophiles</b>			

16. (15 points) For each of the following organisms (Bacteria, Eukaryotes, or Archaeobacteria) indicate (+ / -) whether they have these molecular components.

	<b>Coupled Transcription and Translation</b>	<b>Anaerobic respiration</b>	<b>Some members can fix N<sub>2</sub></b>	<b>16S rRNA subunit</b>	<b>Cap on mRNA</b>
<b>Bacteria</b>					
<b>Eukaryotes (nucleus)</b>					
<b>Archaeobacteria</b>					

We have enjoyed teaching you this semester. We wish you a good holiday.