

1. (9 points) Fill in the following table with respect to bacterial photosynthesis

pathway	reaction center pigment	electron donor	final electron acceptor	name an organism which does this
cyclic photophosphorylation				
photosystem 1				
photosystem 2				

2. (6 points) You are a consultant to a large chemical company. They would like to develop a new pesticide chemical. You are given three proposals. Each compound yields approximately the same results in laboratory tests of pest control (so effectiveness of the compound is not a factor).

- 1) Compound that includes in its chemical structure four chlorines attached to a benzene ring.
- 2) Compound that is similar in structure and composition to chemicals isolated from plants that deter insect colonization.
- 3) Compound that is composed of many repeating compounds forming a polymer.

a) Given this information, which proposal would you suggest the company pursue for development? _____

Why? _____

b) Would you be likely to find bacteria that degrade man-made pesticides in the environment 100 years ago? yes / no

Why? _____

c) Fill in the tables below to indicate the rate at which these three compounds would be degraded in aerobic and anaerobic conditions.

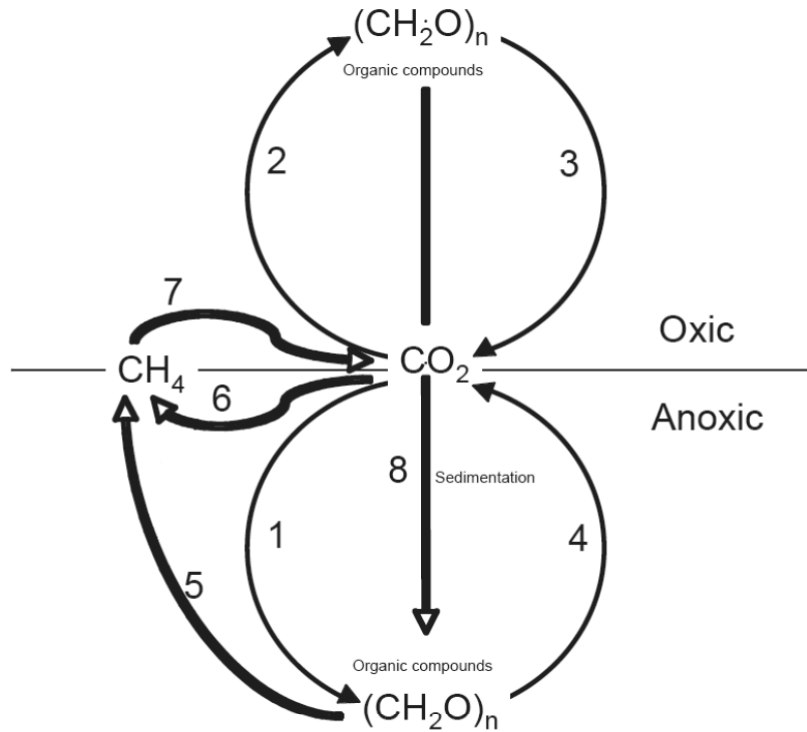
AEROBIC

Fastest	Intermediate	Slowest

ANAEROBIC

Fastest	Intermediate	Slowest

3. (7 points) A diagram depicting the global redox cycle for carbon is shown below.



Indicate the number of the path(s) that matches the given description. An answer (1-8) may be used more than once and more than one pathway may be appropriate for each description, equally an answer of “none” may be appropriate.

- A. oxidation by an obligate anaerobe _____
- B. performed by a oak tree _____
- C. only archaea use these pathways _____
- D. pathway used by organisms in the top layer of a microbial mat today _____
- E. pathway used by organisms in the top layer of a microbial mat 3 billion years ago _____
- F. reduction by an anaerobic photosynthetic bacteria _____
- G. requires light _____

4. (8 points) While studying a previously undescribed deep-sea hydrothermal vent, you identify two species of microorganism. Both species survive by metabolizing sulfur compounds, and do so using the same enzyme.

A friend then says that since they both have the same enzyme, they must be closely related species. Briefly explain why your friend is wrong in this assumption.

What two features (**excluding** cell wall analysis) could you use to identify which domain these microorganisms belong to, and what results would you expect for Archaea and Eubacteria?

Method	Results for Archaea	Results for Eubacteria

5. (6 points) You are studying a piece of swamp land in eastern North Carolina and wish to determine the actual and potential nitrogen fixation in the ecosystem. You have a field plot and can take soil samples from it.

How do you determine the amount of nitrogen fixation presently going on in the soil there?

How do you determine the amount of nitrogenase present in the sample?

You obtain no evidence of nitrogen fixation or nitrogenase. How do you determine whether there are organisms capable of nitrogen fixation present?

6. (8 points) You obtain a spontaneous mutant of *E. coli* which accumulates high levels of histidine (an amino acid with a rather long biosynthetic pathway) when grown in minimal medium with glucose. You know that the enzymes of this pathway are encoded in one large operon. You wish to sequence the minimum amount of DNA to try to find the mutation. Fill in the table below to indicate the **different** genes and sites you consider as possible locations for this mutation.

possible location of mutation	If you added a plasmid carrying a clone of all of the wild type genes for histidine biosynthesis and its regulation to the mutant what would be the resulting phenotype with respect to histidine accumulation?
1.	
2.	
3.	
4.	

7. (6 points) For an immunization to be effective over long periods of time (more than a year) a patient must be able to make and retain what type of B cell (specify)?

What type of cell can the above B cell differentiate into and what is the primary function of this cell.

What cell type does the precursor B cell interact with during the primary adaptive immune response

Provide two mechanisms an invading bacterial pathogen can use to evade innate host defenses.

1. _____

2. _____

8. (6 points) You are a doctor working in a prison hospital in Russia. A patient comes in with a fever, persistent cough, and his chest X-ray reveals cloudy regions with nodules in the lungs.

a) What does he have? _____

b) How should it be treated?

c) Should any public health actions be taken? yes / no
If so, what should be done?

d) There are not enough drugs and not enough money to carry out the treatment plan you detailed above. The man is given five days of rifampin and sent back into the crowded prison population. Why is this a very bad course of treatment?

9. (8 points) You are a doctor in a local hospital in the summer. The patient, Bob, comes in because he lost consciousness at work. Prior to that he was complaining of muscle weakness, headache, and high fever. You note that he has swollen lymph nodes and further tests reveal he is suffering from encephalitis. You find out that he went fishing a few days ago, forgot his mosquito repellent, and was bitten numerous times.

a) What disease does the man have? _____

b) Is there a vaccine for this disease? yes / no

c) Was this disease a problem when Bob's grandfather went fishing in New York in the early 20th century? yes / no

Your next patient is Clara. She has been immunized against chicken pox, hepatitis A and B, and diphtheria, tetanus and whooping cough. She just got back from a visit to Central America. She has a fever, headache, and pronounced jaundice. You notice that she has several insect bites. Further tests reveal that her kidney function is starting to deteriorate and she has started vomiting blood.

d) What disease does Clara have? _____

e) How is it spread? _____

f) Is there a vaccine for this disease? yes / no

g) This virus has an unusual interaction with the immune system. What?

h) Was this disease a problem for Clara's grandmother in New Orleans in the early 20th century?
yes / no

10. (6 points) Why is it true that we can still continue to use the same immunization for polio as we used in the 1960s but must use a different immunization for influenza almost every year? How do the virus strains which cause occasional pandemics arise?

11. (6 points) A new strain of *Clostridium difficile* which causes diarrhea was isolated from an elderly male patient in a hospital in Quebec. The patient had been hospitalized for pneumonia and was treated with penicillin. The new strain of *C. difficile* was highly resistant to several antibiotics including penicillin and also made pili (fimbriae) of a type not seen in previous strains.

a. How could the new strain have become antibiotic resistant? State two **different** mechanisms.

1. _____

2. _____

How could you determine which of your two mechanisms is more likely to be the route by which the bacteria became antibiotic resistant?

Why do you think the production of the pili might have been selected for? What properties would you expect them to have, if your guess is correct?

12. (7 points) Which of the following processes generates energy? Circle them. This question will be graded as correct minus incorrect answers.

- | | | | |
|---|---|--|---|
| photosystem 1 | photosystem 2 | glycolysis | fermentation |
| aerobic respiration | anaerobic respiration | nitrogen fixation | |
| CO ₂ fixation | uptake of glucose | reduction of SO ₄ ²⁻ | reduction of NO ₂ ⁻ |
| oxidation of NO ₂ ⁻ | light absorption by bacterial rhodopsin | reduction of acetylene | |

In the presence of an inhibitor of the proton pump that is able to enter the cells, which of the following processes generates energy? Circle them. This question will be graded as correct minus incorrect answers.

- | | | | |
|---|---|--|---|
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13. (14 points) Fill in the following table

Reaction	Does this reaction (check one box)			Why do organisms carry out this reaction?
	produce energy	consume energy	neither produce nor consume energy	
glucose \rightarrow CO ₂ + H ₂ O				
NO ₂ ⁻ \rightarrow NO ₃ ⁻				
NO ₃ ⁻ \rightarrow NO ₂ ⁻				
H ₂ S \rightarrow S				
CH ₃ OH \rightarrow CH ₄				
CO ₂ + H ₂ O \rightarrow C(H ₂ O)				
N ₂ \rightarrow NH ₃				

14. (9 points) Fill in the following table for 3 **different** examples of symbiosis between a eukaryote and a prokaryote **discussed in lecture in this course**.

prokaryote involved	eukaryote involved	benefit to prokaryote	benefit to eukaryote	biochemical and morphological modification of the eukaryote to accommodate the interaction (list one of each type)	in this ecosystem who is the primary producer and what is the energy source
1.					
2.					
3.					

15. (14 points) Fill out the table below with yes or no, specific naming (as indicated) or denoting that it is not applicable (n/a).

Characteristic	Eubacteria	Archaea	Eukaryote nucleus and cytoplasm	Eukaryote mitochondria and chloroplasts
Presence of operons (yes or no)				XXXXXXXXXX XXXXXXXXXX
Many genes have introns (yes or no)				XXXXXXXXXX XXXXXXXXXX
Initiation of protein synthesis by F-met (yes or no)				XXXXXXXXXX XXXXXXXXXX
Susceptible to diphtheria toxin (yes or no)				
Composition of plasma membrane (name)				
Composition of cell wall (name)				XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX
Some members can use energy from light (yes or no)			<u>Eukaryotes</u>	

We have enjoyed teaching you this semester and we wish you success in your future endeavors.

Have a good holiday!