Part 1. Define or describe the following terms as appropriate. (5 pts. each for 30 pts. total)

orthology

paralogy

unit character

phase variation

type strain

Approved List

Part 2. Fill in the blanks. (3 pts. each for 15 pts. total)

1. During PCR amplificaton of rRNA genes from environmental DNA, two common artifacts are _____ and _____ .

2. Name a method used to identify whole cells of prokaryotes based upon probes to their 16S rRNA. _____ (abbreviations okay)

3. Names two molecular methods used to obtain a fingerprint or a quick survey of the prokatyoes present. _____ and _____ (abbreviations okay)

Part 3. Describe the clonal model for the population structure of prokaryotic species. (10 points)

Part 4. What are stromatolites? (10 points)

Part 5. What practical problems can be solved by studying prokaryotic diversity? (15 points)

Part 5. For the three objects listed below, create a numerical taxonomy that indicates their similarity using the same processes as used for classifying prokaryotes. Include in your answer, a table of characteristics, a scoring scheme, a table of phenetic similarities or distances, and a tree. Please show all work, grading is based upon how you organize your response to the question and not if you get the 'correct' answer. (20 points)

apple
orange
tomato

Part 1. Define or describe the following terms as appropriate. (5 pts. each for 30 pts. total)

natural classification

genospecies

gene tree

homology

activity stain

chimera

Part 2. Fill in the blanks. (3 pts. each for 15 pts. total)

1. Like other organisms, prokaryotes are named according to a binary combination of the:

_____

_____

2. Prokaryotic nomenclature is governed by:

_____

3. To have official standing in nomenclature, the name of a prokaryote must appear in one of these two places:

_____

_____

Part 3. A young microbiologist found some microbial mat lying on the surface of a shallow lagoon in the Bahamas. She took it back to the lab and determined that the fraction of $^{13}C/^{12}C$ was 0.01085. At the same time, she also determined the fraction of $^{13}C/^{12}C$ in the PeeDee belemnite standard, which was 0.01119. What was the $\Delta^{13}C$ (or delta^{13}C) of the sample? (10 points; Please show all work, only partial credit will be given for the answer alone.)

Part 4. What is the clonal model of prokaryotic populations? Is this model correct? Explain your answer. (15 points)

Part 5. The origin of prokaryotes >3.5 Ga predates the origin of eukaryotes by at least 1.5 Ga. What are the implications of this observation on the nature of the eukaryotes? (15 points)

Part 6. Compare the microbial diversity in soil and the gastrointestinal tract. Include in your answer: some of the specific groups, estimates of the culturability of the organisms, and the extent and type of diversity found at each site. (15 points)

Part 1. Define or describe the following terms as appropriate. (5 pts. each for 30 pts. total)

diurnal cycle

reverse electron transport

glyoxylate bypass

specific growth rate

chemotaxis

chemokinesis

Part 2. Fill in the blanks. (2 pts. each for 10 pts. total)

1. What is the oxidation state of the S atom in H_2S? [show calculation]

2. What is the oxidation state of the N atom in NO_2^-? [show calculation]

3. For the Annamox reaction, what is the electron **donor** and what is the electron **acceptor**?

4. For the aerobic nitrifying bacterium *Nitrobacter*, what is the electron **donor** and what is the electron **acceptor**?

5. A two electron oxidation of water produces what compound?

Part 3. Describe some adaptations of the green sulfur bacteria for life in the chemocline. (10 points)

Part 4. Describe the habitat of *Thioploca*. How has this bacterium specialized for growth in this habitat? (15 points)

Part 5. In addition to binary fission, name and briefly describe some other forms of reproduction found within the prokarotes. (15 points)

Part 6. Compare the initial step of methane oxidation by the methane-oxidizing bacteria with the initial step of ammonia oxidation by the nitrifying bacteria. Include in your answer: 1) the name of the enzyme(s) for each reaction, 2) the substrate(s) and product(s) for the reaction catalyzed at the initial step, 3) the relative specificity of the enzymes, and 4) some other interesting properties of each of the enzymes. (20 points)

Part 1. Define or describe the following terms as appropriate. (5 pts. each for 30 pts. total)

mixotroph

autotroph

chemocline

growth yield

greenhouse gas

formaldehyde

Part 2. Fill in the blanks. (3 pts. each for 15 pts. total)

The questions below refer to the heterocyst in filamentous cyanobacteria. Use the correct spellings.

1. The purpose of the heterocyst is to _____.

2. N_2 gas enters the heterocyst through the _____.

3. In the heterocyst, which photosystem is active? _____.

4. Name two enzymes involved in export of fixed N from the heterocyst.

_____, _____

Part 3. Compare photosynthesis in the green and purple bacteria. Include in your answer, the structures of the reaction centers, light-harvesting components, intracellular structures and types of internal membranes, and electron transport chains. (15 points)

Part 4. Compare the serine and the ribulose monophosphate pathways of formaldehyde assimilation. Include in your answer the organisms involved, the names of the key enzymes, discussion of the overall energetics, and anything else you think is important. (10 points)

Part 5. Name and briefly describe the different physiological and phylogenetic groups of nitrifying bacteria. (10 points)

Part 6. Discuss how the midpoint potential of the electron donor to aerobic respiration affects the amount of energy that is available for growth, the electron transport chain and the pathway of NAD^+ reduction. Include in your discussion both some theoretical points as well as at least one concrete example. (20 points)

Part 1. Define or describe the following terms as appropriate. (5 pts. each for 30 pts. total)

capnophile

aerotolerant anaerobe

free radical

carotenoid

food chain

food web

Part 2. Fill in the blanks. (2 pts. each for 20 pts. total)

1. Name **two** genera of sulfate-reducing prokaryotes.

_____ _____

2. Name **two** coenzymes that contain a pterin as part of the chemical structure.

_____ _____

3. Name a substrate that can be an electron donor for anaerobic respiration but can **not** be used for substrate level phosphorylation.

_____

4. For each of the electron **acceptor**s listed below, name (or draw the structure of) a reduced product.

Fe^{+3} _____

NO_3^- _____

AsO_4^{-3} _____

fumarate _____

SO_4^{-2} _____

Part 3. List the substrate, intermediates and product of denitrification *senso stricto*. Indicate which compounds are gaseous and found in significant amounts in the earth's atmosphere. (10 points)

Part 4. Describe how prokaryotes protect themselves from oxygen toxicity. For full credit you should explain at least four different protective mechanisms. (20 points)

Part 5. Compare how the denitrifying bacteria and the sulfate-reducing bacteria generate a proton motive force. Include a possible rationale for the different mechanisms. (10 points).

Part 6. Describe the modifications of the TCA cycle found in some sulfur-reducing bacteria for the oxidation of succinate. Include the likely rationale for this modification. (10 points)

Part 1. Define or describe the following terms as appropriate. (5 pts. each for 30 pts. total)

facultative aerobe

anaerobic respiration

assimilatory sulfate reduction

intermetabolic group

carotenoid

catalase

Part 2. Fill in the blanks. (2 pts. each for 20 pts. total)

1. For each electron acceptor listed below, name or give the chemical formula for the common reduced product:

Fe^{+3} _____

dimethylsulfoxide _____

SeO_4^{-2} _____

fumarate _____

O_2 _____

2. For each reduced product listed below, name or give the chemical formula for the common electron acceptor:

H_2S _____

N_2 _____

succinate _____

acetate _____

S^o _____

Part 3. Name or briefly describe some differences between assimilatory and dissimilatory sulfate reduction. Please be both concise and precise. (10 points)

Part 4. Compare how homoacetogens make a living during growth on H2 + CO2, sugars, and aromatic compounds. Include in your answer the names of key enzymes, overviews of the pathways, energetically important reactions, and anything else you think important. Speculate on whether or not these organisms are generalists or specialists. (20 points)

Part 5. Compare the phylogenetic diversity of the denitrifying, sulfate-reducing and homoacetogenic bacteria. Can this diversity be explained by the biochemical specializations necessary for each life style. Explain your answer, yes or no. (20 points).

Part 1. Define or describe the following terms as appropriate. (5 pts. each for 30 pts. total)

methanofuran

coenzyme M

phosphoanhydride

diagenesis

xenobiotic

nematode

Part 2. Fill in the blanks. (2 pts. each for 20 pts. total)

1. During the fermentation of glucose to **lactate**, _____ATPs are formed and _____ reducing equivalents are produced (give the net value here).

2. During the fermentation of glucose to **acetate**, _____ATPs are formed and _____ reducing equivalents are produced (give the net value here).

3. During the fermentation of glucose to **butanol**, _____ATPs are formed and _____ reducing equivalents are produced (give the net value here).

4. A structure found in the cytoplasm of some prokaryotes that contains a paracrystalline array of the major enzyme of the Calvin cycle ribulose 1,5-bisphosphate carboxylase/oxygenase (or RubisCO) is called:

_____

5. Name the three general types of substrates used by methanogenic archaea:

_____

_____

_____

Part 3. What is the biochemical rationale for the lower acetate threshold in *Methanothrix* than *Methanosarcina*? (10 points)

Part 4. Compare the anaerobic an*d* aerobic degradation of aromatic compounds in terms of A. the number of organisms involved, B. the type of biochemical reactions used to destabilize the aromatic ring, C. the specificity of the organisms, and D. the key intermediates. Whenever possible, be specific! (20 points)

Part 5. How does the presence of a H_2-consuming organisms affect the growth of a syntrophic bacterium on butyrate? (10 points).

Part 6. Describe a symbiosis between a prokaryote (or group of prokaryotes) and an invertebrate. Include in your answer, the name of the prokaryote, the physiological basis for the symbiosis, and a brief summary of the evidence for the symbiosis. (10 points)

Part 1. Define or describe the following terms as appropriate. (5 pts. each for 30 pts. total)

polylactate

nisin

bioremediation

PAH

coenzyme M

nematode

Part 2. For each of the pathways shown below, circle the oxidative and reductive portions. Please notice that some of the pathways might contain more than one oxidative or reductive branch! (15 pts. total)

Part 3. Compare the pathways of aceticlastic methanogenesis and clostridial acetogenesis (from $H_2 + CO_2$). While you do not have to include each step in the pathways for full credit, the names or descriptions of some of the key coenzymes are necessary. Include in your answer, the stoichiometry of the substrates and products for each pathway, ways in which the pathways are similar, ways in which they are different. (20 points)

Part 4. Why is coculture of a H_2-consuming organism necessary for anaerobic growth of a syntrophic bacterium on butyrate? (10 points).

Part 5. Describe the endosymbiont of the aphid. What is the likely benefit to the aphid? (10 points)

Part 6. Compare the degradation of aromatic compounds under aerobic and anaerobic conditions. Include in your answer the major intermediates under each condition, the types of enzymes used to destabilize the aromatic ring, and the specificity of the organisms involved. (15 points).