SES: Methods in Microbial Ecology Fall 2019
Problem Set 6 (*Due 31 Oct 2019*)[*]

1) Plot the concentration of H_2S and CH_4 (if available) (x-axis) versus depth (y-axis). On the graph, also mark the height of the water and the bottom of the sediments (make the downward direction positive with zero at the sediment surface). Make sure to label the axes and curves appropriately (it will be graded). From these data, indicate the approximate depth of the anaerobic interface. Indicate the column sampled, and **please also email me your excel files used to create the plots**. Please include in your excel file both the *raw data* as well as the calculated concentrations.

2) A) The sulfate reducing bacteria in the columns (and in actual sediments) require organic acids and alcohols as C sources, since they are not autotrophs. Where do these organic acids and alcohols come from? (4 pts) B) Why do methanogens usually dominate in freshwater sediments, while sulfate reducing bacteria dominate in marine (i.e., saltwater) sediments? (3 pts) C) What type of chemoorganoheterotrophic bacteria live at the CH_4-O_2 interface? (3 pts)

3) In the following reactions, which compound is the oxidizing agent and which is the reducing agent (note, the oxidizer gets reduced, and the reducer gets oxidized)?

   a) $CH_4 + SO_4^{2-} \rightarrow CO_2 + S^{2-} + 2H_2O$
   b) $5\ H_2S + 8\ NO_3^- \rightarrow 5\ SO_4^{2-} + 4\ N_2 + 4\ H_2O + 2\ H^+$
   c) $C_6H_{12}O_6 \rightarrow 2\ CO_2 + 2\ C_2H_6O$
   d) What is the oxidation state of C in formic acid (CH_2O_2)?

4) A) Say you measure H_2S concentration in a sediment and find that it decreases linearly from 3 mM at 5 cm deep to 1 mM at 0.1 cm below the sediment surface. Assuming an H_2S diffusivity of $5.0 \times 10^{-5}\ m^2\ d^{-1}$, what is the flux (in $mmol/m^2/d$) of H_2S in the sediment? Is the flux into or out of the sediment? There is no advective transport. (8 pts) B) Why are transport processes so important in studying microbial biogeochemistry? (2 pts)

5) A) From the electron tower diagram in the lecture notes, which of the following reactions would release more energy per electron transfer under standard (1 M) conditions, but at pH 7 (note, reaction potential is **independent** of number of electrons that are transferred in a reaction); please explain your answer (4 pts):

   $\frac{1}{2}\ N_2 + 5\ Fe^{3+} + 3\ H_2O \rightarrow 5\ Fe^{2+} + 6\ H^+ + NO_3^-$

   or

   $\frac{1}{2}\ O_2 + 2H^+ + 2Fe^{2+} \rightarrow 2\ Fe^{3+} + H_2O$

   B) How would your answer be affected at high pH's (4 pts)?
   C) Why is the electron tower data often presented at pH 7 instead of pH 0? (2 pts)

6) A) Let us assume that a microbial community has glucose available as an energy source, but the system is anaerobic, and neither light, NO_3^-, SO_4^{2-} nor Fe^{3+} are

[*] Problems continue on back

present, but there is CO_2. What compounds would glucose be converted to that will liberate the greatest amount of energy? Interestingly, no one organism will conduct the overall process, but the community as a whole will. (Think about taking fermentation to its fullest extent.) (6 pts) B) Let us assume that in a dark, anaerobic environment, both Mn^{4+} and SO_4^{2-} are present. Which oxidant, Mn^{4+} or SO_4^{2-}, is likely to be consumed first and why? Assume bacteria have ample nutrients and organic sources. (4 pts)

7) A) Deep-sea hydrothermal vents are fueled by reduced geogasses, such as H_2S and H_2. The primary produces are chemolithoautotrophs, the dominant ones being the sulfur-oxidizing bacteria (at least for many vents). Vent systems are often thought to be decoupled from photosynthesis because the primary producers do not use light. Why is it incorrect to consider vent systems decoupled from photosynthesis (the intensity of light emitted by bioluminescence is far too small to support vent systems, so do not consider that process)? (5 pts) B) What does photosystem I **plus** photosystem II allow that neither photosystem I nor photosystem II do by themselves? (5 pts)

8) A) What type of metabolism probably gives the purple *nonsulfur* bacteria their competitive advantage? B) Why do green sulfur bacteria grow below purple sulfur bacteria in water columns, sediments, and in your Winogradsky columns?

9) A) What gives some sulfur bacteria their white color? B) Why do sulfur bacteria loose their white color when starved of H_2S?

10) A) What compound produces the “rotten egg” smell in the columns and sediments? (4 pts) B) What compound causes the black layer in sediments? (4 pts) C) There are more smells than just “rotten egg” wafting from your columns, what other compounds may contribute to their dubious bouquet? (2 pts)