

Study guide 2

Additional Resources:

Readings from Madigan and Martinko, 2006, *Biology of Microorganisms*
pp. 101-132, 331-350, 531-556, 577-592, and A1. For A1 (the appendix on thermodynamics),
be familiar enough with this section so that you could make calculations similar to those in the
lectures and answer questions based upon these calculations

Readings from Staley et al. 2007, *Microbial Life*
Chapters 6, 8, 9, and 21.

The Prokaryotes, vol. 1; chapter 2 (Stackebrandt)

General nutrition and respiration

Define, distinguish, and/or describe the following terms:

siderophore	$\Delta\psi$
micronutrient	ΔpH
growth factor	flavoprotein
enzyme	cytochrome
catalyst	nonheme iron-protein
NAD/NADH cycling	ferredoxin
fermentation	quinine
respiration	proton motive force
oxidative phosphorylation	Complexes I, II, III, IV
photophosphorylation	ATPase (ATP synthase)
NADH dehydrogenase	citric acid cycle
PMF	glycolysis
	gluconeogenesis

1. What is the elemental composition of the cell, and what are the sources of these elements?
2. How do enzymes catalyze reactions?
3. Why are ATP and acetyl-coenzyme A considered energy-rich compounds? What are some other energy rich compounds?
4. Compare the ways that prokaryotic cells generate a PMF by respiration, photosynthesis and fermentation.
5. How is respiration coupled to biological work? Be able to describe the electron transport chain in *Paracoccus* from the oxidation of NADH to the reduction of O₂.
6. What is the ΔG and why is it important? Given the PMF or the midpoint potentials of the some electron donors and acceptors, calculate the ΔG .
7. From Table A1.2 (given in class), identify potential electron donors and acceptors that might support the growth of prokaryotes. Include possible components of the electron transport chain that could serve as intermediates.
8. Compare the midpoint potentials for various electron donors for aerobes. How does the midpoint potential affects the energy available for growth and the pathway of NAD⁺ reduction.

Photosynthesis

1. In general terms, what types of diversity are found in prokaryotic photosynthesis compared to the chloroplast? Include in your answer a comparison of the phylogeny of photosynthetic prokaryotes, types of reaction centers and light harvesting complexes, types of electron transport chains, types of internal membranes, and types of electron donors.
2. What are the major types of pigments in photosynthetic organisms? Why do organisms have different pigments? What is the difference between light harvesting and reaction center chlorophylls?
3. How do photosynthetic bacteria (purple vs green) form NAD(P)H. Why do they need NAD(P)H anyway?
4. Compare the distribution in nature of the photosynthetic bacteria and the cyanobacteria. Be able to describe a major ecological function or role of a member of each group.
5. Describe the chlorosome.
6. Describe a symbiosis that is common with members of the Chlorobiaceae and some unidentified rod-shaped cells.
7. Describe the major types of organisms related to the cyanobacterial lineage.
8. What types of cellular differentiation occur in the cyanobacteria? What types of developmental cycles occur?
9. Don't worry about knowing the taxonomic scheme for the cyanobacteria if you can answer questions 7 and 8.
10. Compare the roles of prokaryotes and eukaryotes in the total productivity of the ocean. Where are the marine phototrophs found in the ocean?
11. Describe nitrogenase and the energy requirements for N₂ fixation.
12. Describe the heterocyst. How does it protect nitrogenase from O₂? How are nitrogenous compounds transported between the heterocysts and vegetative cells?
13. How do the marine cyanobacteria protect nitrogenase from O₂?

Define, distinguish, and/or describe the following terms:

cyanobacteria	akinete
prochloron	<i>Synechococcus</i>
cyanelle	<i>Prochlorococcus</i>
phycobilin	picoeukaryotes
phycobilisome	nitrogenase
phycobiliproteins	FeMoCo
thylakoid	alternative nitrogenase
tetrapyrrole	microplasmodesmata
chlorophyll	glutamine synthase
reaction center	heterocyst
light harvesting pigments	gas vesicle
budding	glutamate synthase
multiple fission	GOGAT
baecocytes	diurnal cycle
trichome	oxidase
hormogonia	purple bacteria
purple nonsulfur bacteria	
purple sulfur bacteria	
anoxygenic photosynthesis	
oxygenic photosynthesis	
photoheterotroph	
reverse electron transport	
chlorosome	
chemocline	
gas vesicles	
bacteriorhodopsin	
halorhodopsin	
slow rhodopsin	
haloarchaea	

Study guide: sulfur oxidizers, methane oxidizers, nitrifiers

1. Compare the habitats of *Thiovulum*, *Beggiatoa*, and *Thioploca*. How has each organism specialized for its habitat.
2. Describe the sulfur cycle and the role of each of the microbial groups within the cycle.
 - 2a. What chemical transformations are typical of the sulfur oxidizing prokaryotes? Why are many of these organisms acidophiles?
 - 2b. Given the molecular formula of a sulfur, nitrogen or carbon containing compound, calculate the oxidation state of the sulfur, nitrogen or carbon atom (see pp. A1-2).
3. Are the sulfur-oxidizing bacteria a monophyletic group? Explain some of the diversity.
4. How does *Thiovulum* form veils? Why do you suppose it does so? Compare chemotaxis in *Thiovulum* to that common in other prokaryotes, ie. *E. coli*.
7. How does pH affect the free energy available for the iron-oxidizing bacteria? Explain the chemical rationale.
8. Why are the growth yields so poor for the iron-oxidizing bacteria? Are these guys very efficient, ie. do they get most of the energy available from that reaction?
9. How is *Thiobacillus ferrooxidans* used in mining low quality ores? Describe some processes utilized to mine copper, gold and uranium.
10. What is the major geochemical role of the methane-oxidizing bacteria? Why is it important to studies of the greenhouse effect?
11. Compare the soluble and particulate methane monooxygenase of methylotrophic bacteria.
12. What are the other common substrates of the methylotrophs?
13. Compare the serine, ribulose monophosphate and pterin pathways of formaldehyde assimilation? Know the unique steps, the amount of ATP required/C-1 assimilated, and possible physiological differences. How might the RuMP pathway be used to make pentoses?
14. Compare Type I, Type II, and Type X methylotrophs.
15. Describe some symbiosis of methylotrophs with plants and animals.
16. How are methylotrophs used to treat groundwater?
17. Describe the nitrogen cycle on earth, including the microbial groups important at each step and the oxidation state of N.
18. What are the major phylogenetic groups of nitrifying bacteria? What about the anaerobic nitrifying bacteria?
19. Compare the energetics of ammonia and nitrite oxidation. How do nitrifying bacteria reduce NAD^+ ?
20. What are three rationales for the poor growth of the nitrifying bacteria?
21. How much nitrite must be oxidized to reduce NAD^+ ? Why is so much required?
22. Where is the Anammox reaction found? Be able to describe the pathway of ammonia oxidation, the electron donor and electron acceptor.

Define, distinguish, and/or describe the following terms:

specialist	acidophile
generalist	mesophile
mixotrophic	thermophile
chemolithoheterotroph	veils
obligate chemolithotroph	chemotactic
neutrophile	oligotroph

microaerophile
rusticyanin
initiator reaction
propagation cycle
greenhouse gas
methanotroph
methylotroph
one-carbon compound
halomethane
methylamine
methane
methanol
formaldehyde
formate
pMMO
sMMO
serine pathway
RuMP pathway
hexulose-6-phosphate synthase
hexulose phosphate isomerase
serine hydroxymethyl transferase
hydroxypyruvate reductase
malate thiokinase
malyl coenzyme A lyase
glyoxylate bypass

O₂ phobic
tetrahydrofolate
tetrahydromethanopterin
trichloroethene
nitrification
nitrogen cylce
nitric oxide
nitrous oxide
nitrate
nitrite
ammonia
nitrifying bacteria
ammonia-oxidizing bacteria
Nitrospira
ammonia monooxygenase
hydroxylamine oxidoreductase
nitrite-oxidizing bacteria
nitrite oxidoreductase
K_s
Anammox
candidatus
hydrazine-cytochrome c oxidoreductase

Study Guide: H₂ and CO oxidizing bacteria using O₂ as an electron acceptor

1. The bioenergetics under standard conditions for the oxidation of H₂ and carbohydrates are very similar. Why do most H₂-oxidizing bacteria utilize reverse electron transport for NAD⁺ reduction?
2. What are the standard conditions for a reaction? How is the free energy of a reaction calculated under conditions that are not the standard conditions?
3. How is selenocystiene incorporated into proteins?
4. What is the ecology of H₂-oxidizing bacteria? How is the physiology dependent on the ecology?

Define, distinguish, and/or describe the following terms:

knallgas bacteria

hydrogenase

selenocystiene

SelB

carbon monoxide dehydrogenase

molybdenium-pterin coenzyme

membrane-bound hydrogenase

Calvin cycle

reverse citric acid (TCA) cycle

hydroxypropionate cycle

Winogradsky