BIOLOGY 345 **Name** _____

Midterm II - 26 February 2007

PART I. Multiple choice questions – (4 points each, 32 points total).

1. Considering the multitude of potential metabolic processes available to prokaryotes, which of the following is used to *best* describe specific types of **autotrophic** metabolisms?

A. Energy source
B. Carbon source
C. Electron source
D. Hydrogen source
E. All of the above

2. Which of the following **terminal electron acceptors** has the greatest potential to provide the largest amount of free energy?

A. CO_2
B. NO_3^{2-}
C. O_2
D. Fe^{3+}
E. SO_4^{-2}

3. Which of the following **energy and/or electron carriers** contains a nucleotide as part of its molecular structure?

A. $NADH^+ + H^+$
B. $FADH_2$
C. ATP
D. Acetyl CoA
E. All of the above

4. If an oxidation reaction occurs, a reduction reaction must also occur because:

A. Electrons cannot exist alone in solution.
B. A carbon source requires it.
C. Half reactions are written that way.
D. Actually, reduction is not necessary if oxidation occurs.
E. All of the above.

5. As prokaryotes are devoid of autonomous organelles, which of the following pathways does NOT occur exclusively within the **inner face of the cell membrane**?

A. photosynthesis
B. reverse electron flow
C. citric acid cycle aka TCA cycle
D. oxidative-phosphorylation
E. pyruvate oxidation

6. Consider the soluble hydrogenase found in a H-oxidizing bacterium. Which of the following **electron carriers** is directly associated with this hydrogenase?

A. $NADH^+ + H^+$
B. $FADH_2$
C. flavoprotein
D. cytochrome A
E. rusticyanin

7. The elegant **porphyrin ring** made it possible for many metabolic pathways. Which of the following is a combination of an element that can be found in center of a porphyrin ring along with its corresponding metabolic pathway?

A. Co / methanogenesis
B. Fe / photosynthesis
C. Mg / aerobic respiration
D. S / sulphate reduction
E. C / fermentation

8. **Two parts:** (I)Which fermentation pathway is detected using in the methyl red test when differentiating among enteric bacteria? AND (II) Which fermentation pathway is carried out by *Lactococcus* during the production of yogurt? Make sure to circle two answers!

A. Butanediol fermentation
B. Mixed acid fermentation
C. Ethanol fermentation
D. Lactic acid fermentation
E. Proprionic acid fermentation
F. Acetone/Butanol fermentation

PART II. Short answer questions – (Number of points in parentheses, 88 points total).

9. (8 points) What is meant by the statement that: "All bacteria are **osmotrophs**"?

10. (6 points) During what metabolic process are the **source of electrons** and the **source of energy** uncoupled (i.e., not the same)?

11. (12 points) **ATP** is produced by processes known as:

(A) substrate-level phosphorylation,
(B) oxidative-phosphorylation, or
(C) photo-phosphorylation

Indicate (using **A, B, &/or C**) which of the following three phosphorylation reactions listed above are responsible for ATP generation (recycling) in the following types of metabolisms. Note: Some forms of metabolism may involve more than one process.

(I) fermentation –

(II) anaerobic respiration –

(III) aerobic respiration –

(IV) chemolithotrophy –

(V) anoxygenic phototrophy –

(VI) oxygenic phototrophy –

12. (8 points) Consider the process of **reverse electron flow** in a chemolithotroph. Explain when this process is necessary AND name a type of chemolithotrophic organism that requires it.

13. (8 points) What is the **primary problem** that arises as a result of glycolysis that fermentation attends to AND why is this not a problem for anaerobic respirations?

14. (8 points) Briefly describe **two pathways** (there are more) other than the Calvin cycle by which an organism can fix carbon **AND** name the types/group of microorganisms that can use each of these pathways.

15. (6 points) What new twist has recently arisen concerning the ability to produce ATP during fermentation (why is this new format considered so unusual?) AND what are the names of at least one pair of organic acids that are involved?

16. (6 points) Why is the Entner-Doudoroff pathway, when compared to the classical Embden-Myerhof pathway of glycolysis, thought to be the predecessor of the two in terms of efficiency?

17. (6 points) What is the purpose of an **anammoxosome** AND why does it not fit into the usual paradigm regarding membrane bound organelles?

18. (6 points) What is the special feature that is represented by occurrence of **ferredoxin** in phototrophs? (In other words, what can they do that other phototrophs cannot?)

19. (6 points) In what types of metabolic pathways might you find **methylmalonyl-CoA** as well as other interesting-CoA compounds? Also in general terms, what are these CoA compounds used for?

20. (8 points) In terms of **electron donors and acceptors**, why was the development of oxygenic photosynthesis such a major advancement? And, in terms of **light harvesting capability** (e.g., absorption spectra), why are cyanobacteria so efficient at oxygenic photosynthesis?

PART III. Short Essay – (Number of points in parentheses, 30 points total).

21. (15 points) The **endosymbiotic theory** combined with **ribosomal phylogeny** indicates that both mitochondria and chloroplasts were once free-living bacteria (α-*Proteobacteria* and cyanobacteria, respectively). We also consider these organelles to be semi-autonomous as each contains its own localized genomic DNA. As evolution has progressed, the pattern has been the slow but steady transference of organelle gene sequences to the nucleus. The amount of the genome that has been transferred is dramatically **greater in mitochondria than chloroplasts**. **(A)** With what you know about the availability of oxygen, what was the relative occurrence of oxygenic photosynthesis as opposed to aerobic respiration (i.e., which came first)? **(B)** Why does this seem somewhat counterintuitive relative to the occurrence of these organelles in multicellular organisms (i.e., plants & animals)? **(C)** Suggest an explanation as to how you might resolve this conundrum?

22. (15 points) Consider the metabolic menu of microorganisms. **(A)** What are the primary sources of energy, electrons, and carbon for the metabolic processes collectively known as **fermentation** AND anaerobic **chemo(auto)lithotrophy**. You may pick a specific pathway for each to make your point. **(B)** Describe what types of habitats might support each of these types of metabolic processes in nature. **(C)** In general, when it comes to the physical amounts of substrates that must get processed for a given amount of microbial growth, which of these two mechanisms is more efficient, i.e., requires less substrate?