BIOLOGY 345 **Name** _____

Midterm II - 15 November 2010

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

1. Considering the multitude of potential metabolic processes available to *Bacteria* and *Archaea*, which of the following is used to *best* describe specific types of **phototrophic** metabolisms?

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

2. 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.

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

A. SO_4^{2-}
B. H_2
C. O_2
D. Fe^{3+}
E. NH_4^+

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

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

5. There are many ways to produce organic carbon inside the cell, which of the following is NOT considered a mechanisms for fixing CO_2?

A. Calvin cycle
B. Reverse TCA
C. Proteorhodopsin
D. Hydroxyproprionate
E. Methanogenesis

6. Consider the soluble hydrogenase. Which of the following **electron carriers** is directly associated with this hydrogenase?

A. $FADH_2$
B. ferredoxin
C. cytochrome C
D. plastoquinone
E. $NADH+H^+$

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 when using the Voges-Proskauer test? AND (II) Which fermentation pathway is detected when using the methyl red test when differentiating among enteric bacteria? 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. (3 points) What is simply 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 usually 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. (6 points) What is meant by **sulfur disproportionation?** Can you also name a similar type of metabolism for either nitrogen or carbon compounds?

13. (6 points) What is the purpose of an **anammoxosome** AND why does it not fit into the usual paradigm regarding membrane bound organelles?

14. (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?

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. (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?

17. (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?)

18. (6 points) Why do the non-cyanobacterial phototrophs have such a diverse array of bacteriochlorophyll structures and associated carotenoid pigments? In other words, why such diversity among the **anoxygenic photosynthesizers**?

19. (15 points) For the following list of key **enzymes and/or molecular structures**. Your job is to name the group of microorganisms that uses each characteristic enzyme and/or structure **AND** briefly describe how each might be used in that group's characteristic metabolic pathway.

Example – Phosphofructokinase: Heterotrophs Glycolysis

Rusticyanin:

Coenzyme F_{420}:

Membrane-bound Hydrogenase:

Crotonyl-CoA:

Cytochrome C oxidase:

20. (8 points) As aerobic heterotrophic bacteria are devoid of autonomous organelles, **(A)** which two entire metabolic pathways require enzymes that are bound exclusively within the **inner face of the cell membrane**, also **(B)** name one other key pathway where a single enzyme step is also found here? Bonus (4 points) which step in this pathway is it?

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

21. (15 points) Consider the chemoorganotrophic pathways associated with **sulphate-reducing bacteria** (SRBs) and **methanogens**. **(A)** Please describe each groups sources of energy, electrons, and carbon. **(B)** What is the main reason that one group is exclusively made of *Archaea*? **(C)** In terms of redox couples and available free energy, which group do you think could out compete the other if they were found in the same habitat, i.e., the flip-side is, which group has to work the hardest to make its ATP?

22. (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., when did each first occur)? **(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?