

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

1. Which of the following best describes the physiology of a microorganism that receives its energy from light, its electrons from organic molecules, and its carbon from an organic molecule?
 - A. photoautotroph
 - B. chemoautotroph
 - C. photoheterotroph
 - D. chemoheterotroph
 - E. none of the above applies

2. Regarding the lessons learned from the big tree of life, which of the following statements best describes the earliest forms of cellular life?
 - A. The earliest forms of life must have been phototrophs.
 - B. The earliest forms of life must have been acidophiles.
 - C. The earliest forms of life must have been barophiles.
 - D. The earliest forms of life must have been endosymbionts.
 - E. The earliest forms of life must have been thermophiles.

3. 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.

4. **Cryptic growth** is best described when (single best answer only):
 - A. Increases in a cell population are not measured by direct counts.
 - B. Exponential growth is marked by a very long generation time.
 - C. Cells increase in size but not in numbers.
 - D. The number of cells being generated equals the number of cells dying.
 - E. Slowly growing cells occur due to the initial cellular retooling period required when cells are inoculated to a different media type.

5. 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}
6. Which of the following **energy and/or electron carriers** contains a nucleotide as part of its molecular structure?
- A. $\text{NADP}^+ + \text{H}^+$
 - B. FADH_2
 - C. ATP
 - D. Acetyl CoA
 - E. All of the above
7. Turbidity measurements of microbial growth are (single best answer)?
- A. More accurate for dilute samples.
 - B. More accurate for very highly concentrated samples.
 - C. More accurate at mid-range concentrations.
 - D. Equally accurate at mid-range and low concentrations.
 - E. Equally accurate at all three concentrations.
8. **Two parts:** (A) Which fermentation pathway is detected using the Voges-Proskauer? AND (B) Which fermentation pathway is carried out exclusively by obligate anaerobes? Make sure to circle two answers!
- A. Butanediol fermentation
 - B. Mixed acid fermentation
 - C. Ethanol fermentation
 - D. Lactic acid fermentation
 - E. Propionic acid fermentation
 - F. Acetone/Butanol fermentation

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

9. (8 points) Briefly describe what is meant by the **Pasteur Effect**. Specifically, how does this concept apply to the utilization of glucose, the production of ATP, and accumulation of biomass?
10. (6 points) Why is the Entner-Doudoroff pathway, when compared to the classical Embden-Myerhof pathway of glycolysis, thought to be the more ancient of the two in terms of efficiency?
11. (8 points) Briefly explain what is meant by the concept of **compatible solutes** AND name a compound that qualifies as one.
12. (6 points) What is the rate limiting process when considering microbial growth?

13. (8 points) What are the **two characteristic features** of fermentation in general AND what is the **primary problem** that arises as a result of glycolysis that fermentation attends to?
14. (6 points) What new twist has recently arisen concerning the ability to produce ATP during fermentation AND what is the name of at least one organic acid that is involved?
15. (8 points) What major **disadvantage** is there when using O₂ as a terminal electron acceptor and how is this dealt with by prokaryote cells (use at least two specific examples)?
16. (6 points) What is the relationship between generation time and specific growth rate?

17. (8 points) Briefly describe **two pathways** other than the Calvin cycle by which an autotroph can fix carbon **AND** name the types of microorganisms that can use each.
18. (8 points) Briefly describe what is meant by the **Q₁₀ rule** and how it applies to cardinal temperatures.
19. (8 points) Consider the process of **reverse electron flow** in a chemolithotroph. Explain why this process is necessary **AND** name one redox couple that requires it.
20. (8 points) Consider the origins of life hypothesis known as **Thioester World**. What are three characteristics that thioesters are thought to be able to accomplish **AND** name at least one additional chemical transformation they are thought to be responsible for.

PART III. Short Essay – (Number of points in parentheses, 30 points total). Make sure to choose only 2 out of the 3 questions to answer!!! Note: the third essay is extra credit, if you choose to take a shot at it.

- 21.** (15 points) Consider the logical order or progression of the following major metabolic pathways which have occurred during the course of evolution. These include: **simple chemolithotrophy, anoxygenic photosynthesis, chemolithotrophic methanogenesis, anaerobic respiration, and fermentation.** (A) Which two of these pathways must have preceded all of the others? (B) What major molecular achievement made all of the remaining metabolic pathways possible? (C) During what specific **time period** of the Earth's history did this major advancement most likely occur? Provide a brief rationale for each of your arguments.

22. (15 points) Consider the metabolic menu of microorganisms. **(A)** Compare and contrast the primary sources of energy, electrons, and carbon for the metabolic processes collectively known as **anoxygenic photosynthesis** and **oxygenic photosynthesis**. 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)** When it comes to the optimal utilization of the light, which type of microorganisms have the most efficient **absorption spectra** AND with what molecules do they use to optimize their use of it?

23. (15 points) Consider the metabolic menu of microorganisms. **(A)** Compare and contrast the primary sources of energy, electrons, and carbon for the metabolic processes collectively known as **anaerobic respiration** and **chemolithotrophy**. 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?