

PART I. Multiple choice questions – (4 points each, 32 points total). Single best answer!

1. Which of the following **phototrophs** requires reverse electron flow in order to reduce their NAD^+ to $\text{NADH} + \text{H}^+$?
 - A. cyanobacteria
 - B. purple nonsulfur bacteria
 - C. green sulfur bacteria
 - D. halophilic archaea
 - E. Heliobacteria

2. Which of these following **virulence factors** is specifically considered to be antiphagocytic?
 - A. streptokinase
 - B. coagulase
 - C. diphtheria toxin
 - D. hemolysin
 - E. hyaluronidase

3. A deadly viral disease that has been completely eradicated (except for a couple of top-secret freezers) is which of the following?
 - A. Lyme disease
 - B. plague
 - C. anthrax
 - D. chicken pox
 - E. small pox

4. Which of the following is the most common population of microorganisms found in throughout the entire gastrointestinal tract of humans (lower numbers in stomach)?
 - A. *Escherichia coli*
 - B. *Bacteroides vulgatus*
 - C. *Lactobacillus acidophilus*
 - D. *Streptococcus mutans*
 - E. *Methanococcus vanneilii*

5. The 1920's marked the transition into the modern era of microbiology, which was designated because of the discovery of the antibiotic penicillin. Who made this revolutionary discovery and in part was also known as a notorious slob?
- A. Louis Pasteur
 - B. Robert Koch
 - C. Anton van Leeuwenhoek
 - D. Alexander Fleming
 - E. William Clark
6. Ancient stromatolites were most likely inhabited by which of the following types of microorganisms?
- A. cyanobacteria
 - B. purple nonsulfur bacteria
 - C. green sulfur bacteria
 - D. halophilic archaea
 - E. H₂-oxidizing bacteria
7. Consider the major biogeochemical cycles. When it comes to oxygen gas (O₂), what metabolism is considered the ultimate source?
- A. anaerobic respiration
 - B. fermentation
 - C. photosynthesis
 - D. methanogenesis
 - E. sulfur disproportionation
8. When considering the human body (made up of about 10 trillion *Eucarya* cells), which of the following numbers accurately describes how many prokaryotic cells are also involved (i.e., both *Bacteria* and *Archaea*)?
- A. 1 million
 - B. 100 million
 - C. 10 trillion
 - D. 100 trillion
 - E. 1 gazillion

PART II. Matching – (90 points total with one free miss).

9. (3 points each) Considering the phases involved with bacterial **growth** within a population of cells in batch culture, match the characteristics and/or features in the left column with the appropriate phase in the right column by choosing letters A through D (pick a **single** best answer for each).

- | | | |
|-------|--|----------------------------|
| _____ | Synchronous Growth | A. Lag Phase |
| _____ | Cryptic Growth | B. Log Phase |
| _____ | Retooling with new enzymes | C. Stationary Phase |
| _____ | Autolysins are most abundant | D. Death phase |
| _____ | Doubling times are shortest | |
| _____ | Viable counts (CFUs) > Turbidity counts (OD ₆₀₀) | |
| _____ | Turbidity counts (OD ₆₀₀) > Viable counts (CFUs) | |
| _____ | I left my plate of <i>E. coli</i> in the 37°C incubator for over a week. | |
| _____ | A chemostat at equilibrium with high “μ” is most like? | |

10. (3 points each) Indicate if the following characteristics describe exotoxins only (**eXo**), endotoxins only (**enDo**), or both exotoxins and endotoxins (**Both**).

- | | |
|-------|--|
| _____ | Toxins that are more easily inactivated by heat. |
| _____ | Toxins that are comprised of the lipid A component of the LPS layer. |
| _____ | Toxins that are among the most lethal substances known. |
| _____ | Toxins is capable of producing general systemic effects including fever. |
| _____ | AB toxins are an example of these. |
| _____ | True enterotoxins are an example of these. |

11. (3 points each) Certain groups of microorganisms are **physiologically distinct** regarding specific metabolic pathways. Match the microbial group in the left column with the pathway in the right column by choosing letters A through F (pick a **single** best answer for each).

_____	Denitrifiers	A. chemoautolithotrophy
_____	Iron-oxidizers	B. anaerobic respiration
_____	Anaerobic pyruvate reducers	C. aerobic respiration
_____	Cyanobacteria	D. anoxygenic photosynthesis
_____	Green Sulfur Bacteria	E. oxygenic photosynthesis
_____	Methanogens (using CO ₂ only)	F. fermentation
_____	Sulfate Reducers (using organic carbon only)	

12. (3 points each) Considering key (co)enzymes associated with **metabolic pathways**, match the pathway in the right column with a key enzyme in the left column (pick a **single** best answer for each).

_____	ATP synthase	A. Glycolysis
_____	Ferredoxin	B. TCA or Krebs cycle
_____	Crotonase	C. Electron Transport System
_____	Cytochrome oxidase	D. Calvin cycle
_____	Pyruvate kinase	E. Fermentation
_____	Superoxide dismutase	F. Ox/photo phosphorylation
_____	Rubisco (Ribulose bisphosphate carboxylase)	
_____	Succinate dehydrogenase	
_____	Rusticyanin	

PART III. Short answer questions – (Number of points in parentheses, 48 points total).

- 13.** (6 points) If you were an autotrophic bacterium using the Calvin cycle to generate organic carbon, how many **ATP equivalents** does it take to generate a single glucose molecule from CO₂? Is this more or less than the number of **ATP equivalents** derived from catabolizing a single glucose molecule?
- 14.** (6 points) What major **disadvantage** is there when using O₂ as a terminal electron acceptor and how is this dealt with by bacterial cells (use at least two specific examples)?
- 15.** (6 points) Most **barophiles** are also considered another kind of ____ philes. What environmental parameter is also a factor AND why do you suppose this is true considering where they live (i.e., their habitat)?
- 16.** (6 points) Under most circumstances a **chemostat** runs at steady state, however, at a very low or very high dilution rate this rule is violated. Briefly, what happens under these two extreme situations?

17. (6 points) Microbial genetic exchange encompasses transformation, transduction and conjugation. What is the one common **theme** observed throughout microbial genetic exchange AND what is the one **process** also required for each of these to incorporate new information into the genome?
18. (6 points) Briefly, what is the mode of action for **diphtheria** toxin. Why is it so virulent AND what part of the cellular machinery does it shut down?
19. (6 points) The fastest growing bacterium is *E. coli*, which can divide as fast as every ~20 minutes. Under optimal growth conditions, the fastest *E. coli* can replicate an entire genome in ~40 minutes. Briefly, how is ~20 min cell division possible?
20. (6 points) Briefly describe what is meant by the **Q₁₀ rule** and how it applies to cardinal temperatures.

PART IV. Short Essay – (30 points total).

21. (15 points) An unusual photosynthetic microorganism has been found that grows at around 100 meters deep in the ocean. This phototroph is known as a prochlorophyte and is an extremely small single-celled organism just under 1 μm in diameter. During the summer it may reach concentrations up to 5×10^5 cells per ml of seawater. The problem is that though prochlorophytes are similar to cyanobacteria in size and shape, they also contain both chlorophyll *a* and chlorophyll *b* resembling plant chloroplasts. How would you go about proving that these prochlorophytes are actually bacteria?

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 **aerobic respiration (heterotrophic)** AND **oxygenic photosynthesis**. (B) Describe why these pathways are considered to be the “best” in terms of efficiency and ATP production AND which one preceded the other in terms of occurrence regarding free-living bacteria. (C) What types of bacteria specialize in these pathways that have gone on to become semi-autonomous endosymbiotic organelles in multicellular macroorganisms AND what was the relative order for the jump to endosymbiosis for each?