

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

1. An organism that is capable of using CO_2 as a carbon source, using light as its primary energy source, sulfide and/or thiosulfide as an electron donor, and SO_4^{2-} as its electron acceptor, would be best described as which of the following:
 - A. fermentation
 - B. anaerobic respiration
 - C. aerobic respiration
 - D. anoxygenic photosynthesis
 - E. oxygenic photosynthesis

2. An organism that is capable of using acetate as a carbon source, uses H_2 as its electron donor (an energy source), and SO_4 as its electron acceptor, would be best described as having which of the following type of metabolism:
 - A. fermentation
 - B. anaerobic respiration
 - C. aerobic respiration
 - D. anoxygenic photosynthesis
 - E. oxygenic photosynthesis

3. Which of the following microbial species would most likely be considered normal flora when found in association with the human mouth?
 - A. *Escherichia coli*
 - B. *Bacteroides vulgatus*
 - C. *Enterococcus faecalis*
 - D. *Streptococcus mutans*
 - E. *Methanococcus vanneilii*

4. Which of these following **virulence factors** does not represent a kind of invasiveness?
 - A. streptokinase
 - B. coagulase
 - C. diphtheria toxin
 - D. collagenase
 - E. hyaluronidase

5. As microbial genomes get larger and more complex, which of the following types of genes increase in proportionally larger amounts than all other types?
- A. DNA replication
 - B. Translation
 - C. Transcription
 - D. Signal Transduction
 - E. Energy generation (metabolic pathways)
6. The late 1920's marked the transition into the modern era of microbiology, which was designated partly because of the discovery of bacterial transformation. Who made this revolutionary discovery showing naked DNA can convey virulence in *Streptococcus*?
- A. Louis Pasteur
 - B. Robert Koch
 - C. Anton van Leeuwenhoek
 - D. Alexander Fleming
 - E. Fred Griffith
7. Consider the characteristics associated with Endotoxins, which of the following is NOT generally associated with Endotoxins?
- A. Heat Stable
 - B. Weakly immunogenic
 - C. Usually causes fever
 - D. Toxic at relatively low doses
 - E. Lipid A region of the LPS layer
8. There are many ways to produce organic carbon inside the cell, which of the following is **not** considered a mechanism for fixing CO₂?
- A. Calvin cycle
 - B. Reverse TCA
 - C. Proteorhodopsin
 - D. Hydroxypropionate
 - E. Reductive acetyl-CoA

Bonus (4 points): Which one of the above pathways would an autotrophic methanogen use to fix CO₂? Indicate letter here: _____

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 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 steady state with high “μ” is most like? | |

10. (3 points each) Consider the following types of control mechanisms used for gene regulation in Bacteria: **Quorum Sensing, Signal Transduction & Attenuation**. Name the specific type of control that is associated with the following set of characteristics (pick a **single** best answer for each, i.e., **QS, ST or Att**).

- | | |
|-------|---|
| _____ | Uses diffusible autoinducers like homoserine lactones. |
| _____ | Uses two components to regulate porins in <i>Escherichia coli</i> . |
| _____ | Uses a leader sequence downstream from the operator. |
| _____ | Used to control the lux operon in <i>Vibrio fischeri</i> . |
| _____ | Uses feedback from translation to control transcription. |
| _____ | Uses a sensor kinase to transmit environmental cues. |

11. (3 points each) Consider the various environmental forcing functions that affect microbial growth, match the characteristics and/or features in the left column with the appropriate parameter on the right (pick a **single** best answer for each using appropriate letter).

_____	Compatible solutes	A. Temperature
_____	Q ₁₀ rule	B. Pressure
_____	Facultative	C. Oxygen Usage
_____	Barophiles	D. Salinity

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 using appropriate letter).

_____	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
_____	Rusticyanin	G. Pyruvate Oxidation
_____	α -ketoglutarate dehydrogenase complex	
_____	Rubisco (Ribulose biphosphate carboxylase)	
_____	Pyruvate dehydrogenase complex	
_____	Hydrogenase (cytoplasm)	
_____	Alcohol dehydrogenase	

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

- 13.** (6 points) Consider the **Pasteur Effect**. (A) How does this concept apply to the utilization of glucose in terms of what metabolic pathways are possible considering the alternative outcomes? (B) How is the production of ATP numerically impacted and how does ATP get specifically made (name specific process)? (C) How do the possible alternative outcomes impact the accumulation of biomass?
- 14.** (6 points) Describe both a chemotrophic and a phototrophic type of “**two-step**” metabolism that you might consider as the first one to simply generate ATP (i.e., one that you might find in LUCA). What step do they have in common?
- 15.** (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?
- 16.** (6 points) What are two very different energy sources for metabolisms that use **reverse electron flow** and ultimately what is the overall common goal?

17. (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?
18. (6 points) Briefly, what is the mode of action for the **cholera** toxin. What type of therapy is most effective in treating this disease?
19. (6 points) How many **ATP equivalents** does it take to produce one glucose via the Calvin cycle AND is this more or less than a best case scenario for glucose catabolism?
20. (6 points) Name and briefly describe the mechanism of antibiotic mode of action that occurs when a bacterium is sensitive to **penicillin**. Briefly, how is growth affected?

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

- 21.** (15 points) Consider the advent of available concentrations of **O₂ in the atmosphere**. (A) What metabolic pathway lead to this global transition and then what metabolic pathway did this very transition make possible? (B) What conditions had to occur before oxygen could build up in the atmosphere AND what is the geological evidence for this conclusion? (C) What are the disadvantages when using O₂ as a terminal electron acceptor and how is this dealt with by bacteria (provide at least two **specific enzymes** AND their **reaction products**)?

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?