

Midterm I - 25 April 2005

PART I. Multiple choice questions – (4 points each, 36 points total).

1. 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. none

2. From the 1850's to the 1920's, with the many discoveries made by Pasteur, Koch, and Lister, the history of this period of microbiology could best be described as?
 - A. the age of diagnoses
 - B. the age of sanitation
 - C. the age of biotechnology
 - D. the age of discovery
 - E. the age of discontent

3. Considering the multitude of potential metabolic processes available to prokaryotes, which of the following are used to describe specific types of **autotrophic** metabolisms?
 - A. Energy source
 - B. Carbon source
 - C. Electron source
 - D. Hydrogen source
 - E. All of the above

4. The current designation for the highest level of systematic and phylogenetic hierarchical categorization for life is the *Domain*. Which of the following descriptors best fits this designation?
 - A. Prokaryotes and Eukaryotes
 - B. Eubacteria, Archaeobacteria, and Eukaryotes
 - C. Plantae, Protista, Animalia
 - D. Plants, Animals, Fungi, Protozoa, and Monera
 - E. *Bacteria*, *Archaea*, and *Eucarya*

5. Which of the following is NOT a characteristic or function of the cytoplasmic membrane?
- A. Semi-permeable barrier
 - B. Anchor to amphipathic proteins
 - C. Facilitator of PMF (conserves energy)
 - D. A fluid mosaic
 - E. Structural integrity due to turgor pressure
6. Lysozyme is used to break down bacterial cell walls. Which of the following compounds best describes the biomolecular subunits affected by lysozyme's digestive activity?
- A. Diaminopimelic acid (DAP) & D-alanine interbridge
 - B. L-lysine & pentaglycine interbridge
 - C. N-acetylglucosamine (NAG) & N-acetylmuramic acid (NAM) glycan
 - D. N-acetylglucosamine (NAG) & N-acetyltalosaminuronic acid (NAT) glycan
 - E. Dipicolinic acid & Lipoteichoic acid
7. Which of the following structures is NOT found in a typical Gram negative cell wall?
- A. Peptidoglycan cell wall
 - B. Periplasmic space
 - C. LPS layer
 - D. Lipoteichoic acids
 - E. Core polysaccharides
8. Which of the following types of macromolecules contains the greatest amount in terms of numbers of molecules in a typical prokaryotic cell?
- A. RNA
 - B. Lipid
 - C. DNA
 - D. Protein
 - E. Polysaccharide
9. Recently there has been a scientific flurry to better understand the deep subsurface biosphere, what has been described so far?
- A. Nearly the same biomass as seen in surface biosphere
 - B. Nearly all prokaryotic biomass
 - C. Biomass enriched in N and P
 - D. Not as metabolically active as surface biosphere
 - E. All of the above

PART II. Short answer questions – (Number of points in parentheses, 69 points total).

10. (9 points) Consider the structure and function of ribosomes.

A. What are the relative proportions of RNA and protein in a ribosome?

B. Why is it that protein synthesis and transcription are able to be coupled in prokaryotes?

C. Are most eukaryotic ribosomes actually bigger than prokaryotic ones?

11. (12 points) *Yersinia ruckeri* is a bacterium that causes “redmouth” disease first discovered in rainbow trout from the Hagerman Valley, Idaho. It has now spread to the rest of the Western United States, and elsewhere via fish hatchery stocks. This now common disease is characterized by fish with inflammation of the mouth and palate area. Outwardly, the fish become darker in color and sluggish, and the disease is enhanced when fish are stressed and/or when oxygen tension is low. If you were a fish pathologist, how would you **prove** that *Y.ruckerii* is the causative agent of the disease **red mouth**?

- 12.** (17 points) The life cycle of some types of bacteria can alternate between the vegetative cell and the endospore. Included on this list is *Bacillus anthracis*, which has once again reemerged as a serious threat in terms of biowarfare.
- A.** Name the disease associated with this organism?

 - B.** How long can endospores remain viable in general and why?

 - C.** What features do endospores share with vegetative cells?

 - D.** Which endospore structure specifically acts as a water-tight jacket?

 - E.** Name a characteristic compound found only in endospores?

 - F.** What is the *practical* significance of the teichoic acid component of *B. anthracis* cell walls?
- 13.** (5 points) You have a culture of your favorite cyanobacteria and are wondering if they have gas vesicles. How might you still go about testing for this variant structure even if you don't have a microscope handy?

- 14.** (15 points) Briefly discuss the importance and the function for each of the following variant compounds as they relate to microbial cells. Please indicate where this structure is found in the cell AND if the structure is exclusively in Gram-positive *Bacteria*, Gram-negative *Bacteria*, or *Archaea*.
- A. Hopanoids –

 - B. Pentaglycine interbridge –

 - C. Porins –

 - D. Biphytanyl tetraether lipids –

 - E. N-Acetyltalosaminuronic acid (NAT) –
- 15.** (5 points) What is the significance of the bacterium *Aquifex pyrophilus* having a cell membrane with only phospholipids, but with both ester and ether linkages?
- 16.** (6 points) Consider all the macromolecules responsible for energy transfer during aerobic respiration. What structural component do they all have in common AND which one is your favorite (why)?

PART III. Short Essay – (Number of points in parentheses, 45 points total).

- 17.** (15 points) You are conducting undergraduate research for a professor who gives you a viable culture labeled *Gemmata obscuriglobus*. He tells you that it is a member of the order *Planctomycetales*, a rather unusual group of *Bacteria*, and proceeds to leave town for a sabbatical. You determine through standard microbiological methods that this “bacterium” has no peptidoglycan in its’ cell wall (only proteins) and that it has a membrane bound nucleoid. **(A)** First, you decide your professor suffers from alzheimer's. Why would you think this based on the usual taxonomic characteristics of bacteria? **(B)** You decide to keep studying this organism anyway, and design an experiment to determine if *G. obscuriglobus* is really a member of the domain *Bacteria*. How would you go about conducting this experiment based on a **phylogenetic** approach? **(C)** Why might a phylogenetic approach be a better choice than a taxonomic one in this case?

- 18.** (15 points) Consider the lessons that can be learned by examining the BIG TREE OF LIFE. **(A)** What types of characteristics does the general topology of the tree point towards as the earliest cellular life forms emerged AND how does it support the endosymbiotic theory for some organelles in terms of occurring sometime thereafter? **(B)** Even though the branch lengths (or clock speed) tends to be shorter for the *Archaea*, why do we NOT consider them to be primitive, but instead just less complex? **(C)** What additional clues has genome sequencing and functional genomics added to the big tree of life perspective?

- 19.** (15 points) A new giant bacterium has recently been discovered in marine sediments, named *Thiomargarita namibiensis*. This bacterium has a coccoid morphology and grows as a “string of pearls” measuring up to **0.5 mm** in diameter. It also shines white (i.e., the pearl-look) due to large refractive sulfur inclusion bodies contained inside of the cell. **(A)** Based on this information and what you already know about surface area to volume ratios, what are the major problems that this bacterium must overcome? **(B)** What advantage might this bacterium have achieved by being so large? **(C)** What is the “normal” size range for most free-living bacteria and why?