Multiple choice. (1 point each) Choose the one best answer to each of the following questions.

1. _A_ The earliest stromatolites were probably

   A. anoxygenic phototrophs  
   B. anoxygenic lithotrophs  
   C. oxygenic phototrophs  
   D. oxygenic lithotrophs  

2. _C_ The most abundant gases in the early atmosphere of the Earth were probably

   A. CH₄, CO₂, O₂, N₂  
   B. CH₄, H₂, O₂, N₂  
   C. CH₄, CO₂, NH₃, N₂  
   D. H₂, CO₂, O₂, N₂  

3. _A_ Compared to today, the temperature on Earth during its first half billion years was probably

   A. considerably warmer (averaging perhaps 100°C).  
   B. considerably colder (averaging perhaps 10°C).  
   C. about the same as today.  
   D. about the same as today on average but the diurnal fluctuations were much greater.  

4. _B_ Macromolecules on primitive earth were probably polymerized by

   A. enzymatic interaction.  
   B. dehydration synthesis.  
   C. Electron transport systems.  
   D. mechanisms as yet unetermined.  

5. _C_ The earliest RNA probably functioned in

   A. catalysis  
   B. genetic coding  
   C. both catalysis and genetic coding  
   D. neither catalysis nor genetic coding  

6. _A_ The cyanobacteria probably evolved from

   A. anoxygenic phototrophs  
   B. anoxygenic lithotrophs  
   C. oxygenic phototrophs  
   D. oxygenic lithotrophs  

7. _C_ The most widely used molecular chronometer is

   A. cytochrome C  
   B. ATPase  
   C. ribosomal RNA  
   D. heat shock proteins  

8. _B_ The size of the most useful RNA molecule for prokaryotic evolutionary studies is

   A. 5S  
   B. 16S  
   C. 18S  
   D. 23S
9. _ A _ Organisms of which domain occupy the environments closest to those of primitive earth?

A. Archaea  
B. Eubacteria  
C. Eukarya  
D. Organisms from all domains can be found in primitive areas.

10. _ A _ Molecular sequencing suggests that mitochondria arose from a group of prokaryotic organisms that includes the

A. Agrobacterium and Rhizobium  
B. Vibrio and Photobacterium  
C. Aquifex  
D. Escherichia and Salmonella

11. _ C _ At the present time, how many bacterial divisions (kingdoms) have been identified?

A. 4, but the actual number may be as high as 10  
B. 8, but the actual number may be as high as 16  
C. 14, but the actual number may be as high as 50  
D. 50, but the actual number may be as high as 150

12. _ C _ The eukaryotic functional equivalent of the prokaryotic 16S rRNA is the

A. 5S rRNA  
B. 16S rRNA (the same as the prokaryotic 16S rRNA)  
C. 18S rRNA  
D. 23S rRNA

13. _ A _ Although the microsporidia and diplomonads are eukaryotic, they lack

A. mitochondria  
B. a true nucleus  
C. identifiable ribosomes  
D. all of the above

14. _ B _ Protein synthesis studies using Sulfolobus (archaea), yeast (eukarya), and Escherichia coli (eubacteria) indicate that the ribosomal proteins of _____ and _____ are more closely related to each other than they are to the ribosomal proteins of _____.

A. archaea, eubacteria, eukarya  
B. archaea, eukarya, eubacteria  
C. eubacteria, eukarya, archaea  
D. none of the above because the studies indicate these proteins all seem to be similar.

15. _ A _ All eukaryotes contain

A. a membrane bound nucleus  
B. mitochondria  
C. hydrogenosomes  
D. all of the above

16. _ B _ Mitochondria

A. utilize the Calvin-Benson cycle.  
B. utilize the citric acid cycle.  
C. reduce organic compounds to CO₂.  
D. all of the above.
17. **B** On the evolutionary scale, which of the following organisms is probably the oldest?

A. *Trichomonas*
B. *Giardia*
C. *Escherichia coli*
D. this cannot be determined

18. **A** A thin, crescent-shaped organism with a single flagellum originating from a basal body would most likely be a member of the genus

A. *Trypanosoma*
B. *Glossina*
C. *Entamoeba*
D. *Gambiense*

19. **A** The apicomplexa are characterized by

A. obligate parasitism.
B. undulating motility in the adult stages.
C. external digestion of food particles.
D. all of the above

20. **C** Which statement best describes the habitats of the fungi?

A. Most fungi are aquatic, primarily fresh water aquatic.
B. Most fungi are aquatic, primarily marine aquatic.
C. Most terrestrial fungi dwell in the soil or on dead plant material.
D. Most terrestrial fungi are plant or animal parasites.

21. **B** Which statement is true?

A. Fungal cell walls resemble plant cell walls chemically but not architecturally.
B. Fungal cell walls resemble plant cell walls architecturally but not chemically.
C. fungal cell walls resemble plant cell walls both chemically and architecturally.
D. Fungal cell walls do not resemble plant cell walls either chemically or architecturally.

22. **D** Which statement is true?

A. Conidia are asexual spores.
B. Ascospores are sexual spores.
C. Basidiospores are sexual spores.
D. all of the above are true.

23. **C** Which algae are probably most closely related to the plants?

A. diatoms
B. brown algae
C. green algae
D. euglenoids

24. **A** Euglenoids are close phylogenetic relatives of the

A. flagellated protozoa.
B. ciliated protozoa.
C. ameoboid protozoa
D. sporozoans

25. **A** The chloroplasts of red algae contain __, which is also the main light harvesting pigment found in ___.

A. phycobiliproteins/cyanobacteria
B. bacteriochlorophyl/purple bacteria
C. bacteriorhodopsin/halobacteria
26. _ **A** _ Which of the following traits is not characteristic of Caulobacter?

A. Occurs in aquatic habitats rich in organic matter.
B. Produces a cytoplasmic outgrowth (prostheca)
C. Attaches to surfaces in nature
D. Forms rosettes.

27. _ **D** _ Which of the following characterize the Actinomycetes?

A. Filamentous growth.
B. Conidia on aerial hyphae.
C. Common inhabitants of soil.
D. All of the above.

28. _ **B** _ Which of the following would not apply to Bdellovibrio?

A. Obligate aerobe.
B. Attacks Gram positive bacteria
C. Replicates in periplasmic space.
D. Widespread in soil.

29. _ **B** _ Which of the following gliding bacteria form(s) fruiting bodies?

A. Beggiatoa
B. Myxococcus
C. Cytophaga
D. All of the above form fruiting bodies.

30. _ **A** _ Members of the genus Pseudomonas

A. may have fluorescent pigments
B. usually have peritrichous flagella.
C. are gram positive rods.
D. tend to cause mild (rather than serious) infections in humans.

31. _ **B** _ Which of the following is not a trait of the rickettsia?

A. Obligate intracellular parasite.
B. Lack a cell wall.
C. Contain both RNA and DNA.
D. Distinct energy metabolism.

32. _ **C** _ Which of the following statements does not correctly apply to magnetotactic bacteria?

A. The cells contain particles of Fe₃O₄.
B. Magnetic orientation may provide a means for migrating towards microaerobic zones in sediments.
C. The bacteria align their long axis at right angles to the lines of the magnetic fields.
D. In cells from the Northern hemisphere magnetosomes align themselves forward with respect to the flagella which propel cells along the magnetic field.

33. _ **A** _ A gram positive microorganism has the following traits: filamentous, forms spores at the end of mycelia, produces antibiotics, produces geosmin, is nutritionally versatile, yields compact "dusty" colonies on agar culture media. These traits describe the genus

A. Streptomyces
B. Streptobacillus
C. Mycobacterium
D. Lactobacillus
34. **C** Which statement(s) is/are not true of the organisms in the domain archaea?

A. These organisms lack peptidoglycan in their cell walls.
B. These organisms contain ether-linked lipids.
C. These organisms have simple RNA polymerases.
D. All of the above.

35. **B** Which statement is true?

A. The methanogens are obligate aerobes and the extreme halophiles are obligate anaerobes.
B. The methanogens are obligate anaerobes and the extreme halophiles are obligate aerobes.
C. Both the methanogens and the extreme halophiles are obligate aerobes.
D. Both the methanogens and the extreme halophiles are obligate anaerobes.

36. **A** Methanogens

A. produce methane as a part of their energy metabolism.
B. utilize methane as an energy source.
C. process and store methane as a part of their repair mechanisms.
D. do none of the above.

37. **D** *Picrophilus* is capable of growth

A. above pH 14
B. Only in the pH 10-12 range.
C. Only in the pH 2-4 range.
D. Near pH 0.

38. **D** Which of the following is/are true about *Sulfolobus*?

A. *Sulfolobus* grows in sulfur-rich hot acid springs.
B. *Sulfolobus* is an aerobic chemolithotroph.
C. *Sulfolobus* can grow chemoorganotrophically.
D. all of the above.

**Short answer.** (1 point each answer)

1. Fossilized microbial mats consisting of layers of filamentous prokaryotes and trapped sediment are known as **Stromatolites**.
2. The development of the enclosed, self-replicating RNA life forms within lipoprotein vesicles may have been the evolutionary path leading to the **cell**.
3. Filamentous fungi are known as **molds**.
4. The term used for the vegetative mass of the acellular clime molds is **plasmodia**.
5. The Tsetse fly is the arthropod vector involved in the transmission of African sleeping sickness which is caused by a member of the genus **Trypanosoma**.
6. The **capsid** is the protein coat of a virus.
7. Silica is a characteristic component of which type of algae?
   **Diatoms**
8. Which three major categories of eukaryotic cells are commonly bounded by a cell wall?
   **Plants, Algae, Fungi**
9. Why do most fungi have cell walls made of chitin instead of cellulose?
   **Because they digest the cellulose of plants using extracellular enzymes that degrade cellulose.**
10. What is a temperate (lysogenic) phage? A phage that integrates its genome in the host genome and becomes lytic after an insult to the host cell.
Describe the use of 16S rRNA sequences as a means of measuring the phylogenetic relationship between different organisms. Include the features of this molecule, why this molecule is used, how it compares to other possible chronometers and what information has been obtained from 16S rRNA sequences analysis.

16S rRNA is used to measure phylogenetic relationships among different organisms by determining the number of differences between optimally aligned sequences. Once the rRNA sequence is determined for an organism, it is aligned with known rRNA sequences in order to maximize the number of matching bases. Once the alignment is made the number of differences is determined. The greater the number of differences, the more distantly related two organisms are likely to be. In other words, the longer it has been since each organism shared a common ancestor. This analysis must also account for the possibility that changes may also occur that result in reverting a base back to the original sequence. With multiple sequences "trees" can be drawn to represent the evolutionary distances between organisms. A number of trees can be drawn but eventually one tree is identified that optimally represents the distances between all organisms being compared.

16S rRNA is a useful chronometer because it is found in all living organisms, it is large (>1500 bp), it has some regions that are conserved among domains or kingdoms and other regions that are highly variable even among genera. Other major molecules that have been used as evolutionary chronometers include ATPase, heat shock proteins and cytochromes but none of these molecules has as many advantages as the 16S rRNA sequence.

Some of the things that we have learned from 16S/18S rRNA sequence analysis include the determination that there is a universal tree of life which includes 3 domains - one of which (Archaea) was first identified based on 16S rRNA analysis. It was also learned that some regions are highly conserved providing signature sequences that are specific for domains or families and some regions are highly variable that are most useful for evolutionary analysis within a particular domain or family. It was also learned that mitochondria are most closely related to members of the α subgroup of the proteobacteria.
Short Essay Questions. Please answer 2 of the following 3 short essay questions (5 points each - 5 bonus points possible for answering all three questions)

Describe the life cycle of the cellular slime mold Dictyostelium.

The cellular slime molds undergo a complex life cycle which is an asexual process. Vegetative cells live independently in the soil until nutrient deprivation triggers aggregation. Aggregation is signaled by cAMP and specific glycoproteins. The aggregated vegetative cells form a structure called a pseudoplasmodium. Eventually the Pseudoplasmodium differentiates into a slug and is motile by amoeboid like motility. The slug differentiates into a fruiting body in a dramatic differentiation process. First the anterior portion of the slug differentiates into stalk cells and then cells from posterior portion form the "Head" cells. Cells of the fruiting body undergo meiosis to form spores. The cellular slime molds can also undergo a process of sexual reproduction that involves specialized cells called macrocysts.

Discuss the differences between bacterial endospores, myxobacterial spores, fungal spores, sporozoites and macrocysts. Include the function of the each and their relative heat and dessication resistances.

The bacterial endospore is the most heat and dessication resistant of each of these structures. Endospores provide for extremely long term survival of the organisms under very harsh conditions. Myxobacterial spores and fungal spores are similar in their heat and dessication resistance. These spores mainly function as a means of disseminating the organism to a new location where more nutrients may be available. By being produced on the ends of aerial hyphae (fungal spores) or at the top of a fruiting body (myxospores) the spores can be readily picked up by passing animals or blown by the wind for distribution to new environments. Sporozoites and macrocysts are the least heat and dessication resistant. The sporozoites are merely a stage in the lifecycle of the apicomplexans and function in transmission of the organism whereas macrocysts are cells of the cellular slime mold that are involved in sexual reproduction.
Describe the Baltimore classification scheme for viruses including each class of virus.

The Baltimore classification scheme for viruses is based on the relationship of the viral genome to mRNA. Based on this scheme there are 6 classes of viruses.

Class I viruses are double-stranded DNA viruses that simply contain promoter elements that direct transcription to produce mRNA.

Class II viruses are single-stranded DNA viruses. Single-stranded DNA viruses require synthesis of a second DNA strand before the DNA can be transcribed to produce mRNA. Single-stranded DNA viruses can be either positive (Class IIA) or negative strand (Class IIB) viruses but unlike the single-stranded RNA viruses, they are grouped together because no matter which strand they start with, a double-stranded DNA intermediate must be made before transcription can occur.

Class III viruses are double-stranded RNA viruses. After infection of a cell by a class III virus, the positive strand will serve directly as a mRNA.

Class IV viruses are single-stranded RNA viruses and the genome represents the positive strand. Therefore, the viral genome can serve directly as the mRNA.

Class V viruses are also single-stranded RNA viruses but the genome represents the negative strand. Therefore, the viral genome must serve as a template for the synthesis of a positive strand which can then serve as a mRNA. There are two subclasses of Class V viruses (a & b) that are distinguished based upon their mechanism of expression and replication.

Class VI viruses are the retroviruses. These are positive single-stranded viruses like the Class IV viruses but unlike the Class IV viruses, the positive strand RNA cannot serve as a mRNA. Instead, the RNA genome serves as a template for the synthesis of a double-stranded DNA intermediate. This requires a special enzyme called reverse transcriptase.