Study Guide
MICROBIAL DIVERSITY
BROCK CH. 13

This study guide covers **Brock Ch. 13** – the Archaea. I will hand out Table 11.3, which is referenced at the start of this chapter. **Note that Brock uses 'Archaeon' when we use 'Archaean'. Both are acceptable in the literature and in this course, although 'Archaean' is more typically used in the US.**

1. Name at least three characteristics shared by all archaeans.

2. The domain Archaea is made up of three phyla. Fill in the table below:

Phylum	Sister group of phylum	Example taxon

a. Which phylum contains the majority of hyperthermophiles?

i. Most hyperthermophiles in the group named in (a), which survive at the highest temperatures known to support life, are _____. As a result, most of these extreme environments do not have photosynthetic organisms as their primary producers.

ii. Most hyperthermophiles in this group have 'short branches' on the tree of life. What do short branches on the tree tell us about the evolutionary rate of their genomes?

i. What would long branches tell us?

b. Which phylum contains the majority of methanogens?

i. Methanogens are obligate anaerobes. What does this mean?

ii. Halophilic archaeans are closely related to methanogens.

i. What conditions to halophiles favor?

ii. Most halophiles, although close relatives of methanogens, are obligate _____.

iii. This phylum also includes some hyperthermophiles, including *Thermococcus* and *Pyrococcus*. Given our current understanding, are the hyperthermophilic Archaea monophyletic? Explain.

3. Where were the Korarchaeota first found?

i. Why is the name of this phylum in quotes in the reading assignment?

4. True or false: archaeans include chemolithotrophic, chemoorganotrophic, and autotrophic species.

5. With the exception of methanogenesis, many of the metabolic processes found in Archaea are also found in _____.

***Questions 6-22 refer to the Euryarchaeota*.**

6. Give an example of a *hypersaline* environment, and an example of the habitat of an *extreme halophile*.

7. True or false: Archaea are often the only organisms in extreme salt lakes.

8. What are marine salterns?

9. What is misleading about the name '*Halobacterium*'?

10. True or false: all extreme halophiles have the same morphology.

11. True or false: all extreme halophiles have high GC content in their DNA.

12. Imagine that you had a culture of rod-shaped Archaea with a GC content of 70%. You want to know what genus these Archaea belong to. What simple test could you do to identify these archaeans to genus?

13. Halophilic Archaea share which of the following characteristics (circle all that apply):
    a. Stain gram-negative
    b. Reproduce by binary fission
    c. Do not form resting stages
    d. Make a living by chemoorganotrophy

14. One of the major challenges for life in extremely saline environments lies in osmotic regulation. One way that Archaea do it is to accumulate or synthesize organic compounds within their cells. These compounds are called **compatible solutes,** and they prevent dehydration of balancing the osmotic potential of the cell with the surrounding environment. What ion is used in this way by *Halobacterium*?

    a. What's distinctive about the cell wall of *Halobacterium* relative to the environment in which this archaean is found?

15. One neat aspect of some halophilic Archaea is their ability to **synthesize ATP using light**. This is **not** photosynthesis because _____ is not involved.

16. List the five main habitats of methanogenic archaea.

17. Methanogenic Archaea are obligate anaerobes. What sorts of conditions are used to culture these organisms?

18. At least 11 different substrates can be used to make methane by methanogenic Archaea. It is interesting that glucose, an important sugar for much microbial growth, cannot be used to generate methane by Archaea without assistance from other organisms. Three major classes of compounds make up most of the methanogenic substrates. List the classes and give an example of each.

19. The entire genome of *Methanocaldococcus jannaschii*, a methanogenic archaean, has been sequenced. What aspects of the genome of this archean support the placement of the archaea between the other two domains of cellular life?

20. The Thermoplasmatales are a phylogenetically distinct lineage of Archaea that these includes thermophilic and acidophilic taxa: *Thermoplasma, Ferroplasma,* and *Picrophilus*. What is distinctive about *Picrophilus*?

    a. *Thermoplasma acidophilum* has the following characteristics (circle all that apply):
        A. Chemoorganotrophic lifestyle
        B. Prefers warm, strongly acidic conditions
        C. Can grow anaerobically and aerobically
        D. Lacks a cell walll
        E. Are often found in self-heating coal piles
        F. Have a unique cell membrane that is heat- and acid-resistant

21. Hyperthermophilic Euryarchaeota include *Thermococcus* and *Pyrococcus*, and *Methanopyrus.* How is *Methanopyrus* distinct from the other methanogens described in this chapter?

a. *Thermococcus* have the following characteristics (circle all that apply):
   - *A.* Branch near the base of the Euryarchaeota
   - *B.* Spherical morphology
   - *C.* Chemoorganotrophic lifestyle
   - *D.* Anaerobic metabolism
   - *E.* Preference for temperatures ranging from 70-95°C

b. What factor can be used to differentiate *Thermococcus* from *Pyrococcus*?

   i. What does *Pyrococcus* mean (from the Latin roots)?

c. *Methanopyrus* has been isolated from sediments near sub-marine _____, This group grows quickly at 100°C and has a unique lipid membrane relative to all other known organisms.

22. Which of the hyperthermophilic Euryarchaeota is a true sulfate-reducer? What order is this genus in? (An order ends in the suffix '-ales').

***Questions 23-27 focus on the Crenarchaeota*.**

23. Most Crenarchaeota are hyperthermophiles, and some have optimal growing conditions _____ of water. Most Crenarchaeota (the hyperthermophiles) are obligate _____. Crenarchaeota are heterotrophs, making a living by two methods:_____.

24. What are solfataras? Define them, and describe the conditions present in them.

25. True or false: water boils at a much higher temperature (for example, >350°C) in the deep sea than it does on the surface.

26. Crenarchaeotans from terrestrial volcanic habitats include what three important genera? What these are members of which orders? What habitat does each genus grow in, and how does each one make a living? (You may wish to represent these pieces of information in a table).

27. Crenarchaeotans from submarine volcanic habitats are the Desulfurococcales, including the genera *Pyrodictium, Pyrolobus, Ignicoccus, and Staphylothermus*. What's remarkable about *Pyrolobus fumarii*?

    a. Describe the morphology of this species, the nature of its cell wall, and the way in which this species makes a living.

    b. What characteristics can be used to distinguish between *Staphylothermus* and *Ignicoccus*?

28. What two components of life must be stabilized to permit life at high temperatures?

29. What aspects of proteins are most important for their heat resistance?

30. What is a chaperonin? Give one example of a chaperonin, and indicate the organism that produces it and the conditions under which that organism lives.

31. What is the role and significance of reverse DNA gyrase?

32. Give two reasons for which there is likely to be an absolute upper temperature limit for the existence of life.

33. Many archaeans are thought to have evolved at a slower rate than most bacteria or eucarya. As noted above, this is especially true among the hyperthermophilic archaea. Interestingly, slow evolution is also found among the hyperthermophilic bacteria. Describe one hypothesis for the 'slow evolutionary clocks' of hyperthermophilic organisms.