The Three Domains
AP Biology
San Pasqual High School

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There is a growing trend in biology(especially microbiology) to place all living things into three Domains. Carl Woese first proposed this system in 1980. A Domain is a classification category above Kingdom. This new system is based on investigations of an ancient group of bacteria-like organisms formerly known as the Archaebacteria, now referred to as the Archaea. Investigations of ribosomal RNA and other features of these groups has led to this new system. Evidence indicates that the three Domains diverged early in the history of life(3.5-4 billion years ago) with bacteria branching off before Archaea and Eukarya. Many of the Archaea are anaerobic and live in harsh environments such as high temperature(up to 113EC) and high salinity(up to 5.5M NaCl).

As an interesting sidelight to this story, this new system often includes chloroplasts and mitochondria. Mitochondria are placed near purple bacteria and chloroplasts near the cyanobacteria(blue-green algae) in Brock et al.(1994). The endosymbiotic hypothesis holds that these organelles are descended from once free-living bacteria, analysis of ribosomal RNA supports this hypothesis.

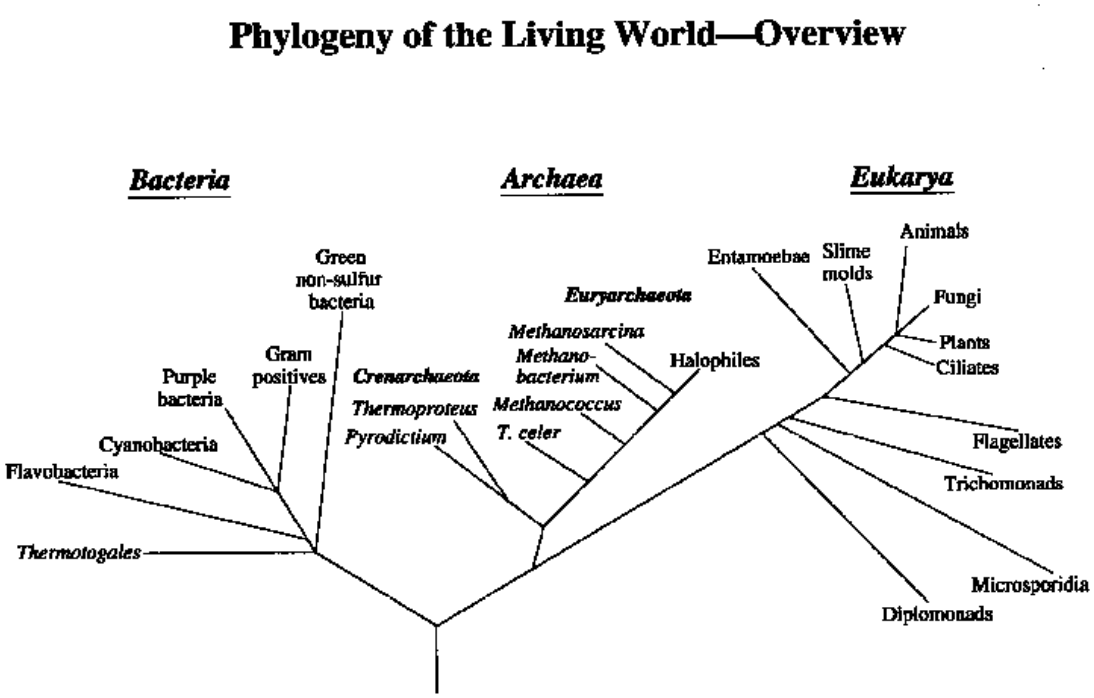
Characteristics of the three Domains

(Modified from Brock,T.D., et al. 1994. Biology of Microorganisms. Prentice Hall. Englewood Cliffs, NJ.)

Characteristic	Bacteria(Monera)	Archaea (Archaebacteria)	Eukarya (Eukaryotes)
Membrane Bound Nucleus	Absent	Absent	Present
Cell Wall	Contains Peptidoglycan	No Peptidoglycan, most contain glycoprotein	None or cellulose(plants) or chitin(fungi)
Chlorophyll Based Photosynthesis	Yes	No	Yes
Plasmids Present	Yes	Yes	Rare
Operons	Yes	Yes	No
Methanogenesis	No	Yes	No
Ribosome Size[1]	70S	70S	80S
Capping and poly A tails in mRNA	No	No	Yes
RNA Polymerases	One(4 subunits)	Several(8-12 subunits)	Three(12-14 subunits)
Genetic Material	DNA	DNA	DNA
Membrane Phospholipids	Ester Linked	Ether Linked	Ester Linked

[1](S=Svedberg units; a measure of sedimentation rate in a centrifuge; thus a measure of size)

Phylogenetic tree of the three Domains based on ribosomal RNA sequencing. (Brock,T.D., et al., 1994)



Overview of Archaea

The Archaea are possibly not bacteria in the traditional sense. They differ from the Monera(Eubacteria) in three main ways: 1) they cell walls do not contain peptidoglycan; 2) the lipids of their cell membranes are unusual; 3) their DNA base sequences are more than 50% different from the DNA of the Monera.

Archaea are also known for their preferred living conditions. They are often referred to as "*extremophiles*", or "extreme lovers". They are found in hot springs, deep ocean vents and salt lakes. Some of these organisms even live in hot acidic environments, they are referred to as *thermoacidophiles*. Those living in salty environments are called "*halophiles*"(halo=salt). *Methanogens* are Archaea that produce methane, Methonogens live in anaerobic conditions such as mash bottoms, intestines and in underground rocks.

Archaea Web Sites
(January 2001)

http://www.sidwell.edu/us/science/vlb5/Labs/Classification_Lab/Archaea/
http://www.srv.net/~tntz/microbes/archaea.html
http://www.personal.psu.edu/users/e/e/ees135/