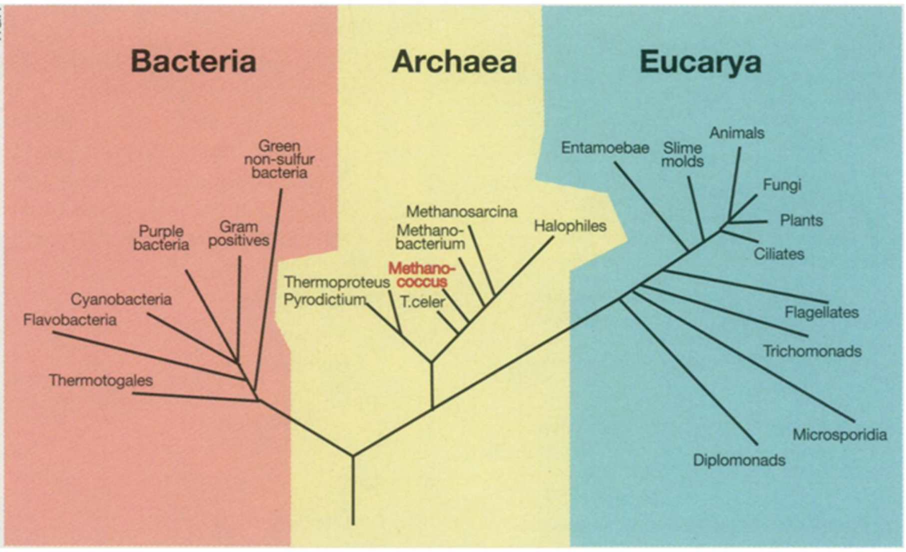
Third Branch of Life Bares Its Genes

For eons, the methane-belching microorganisms lived anonymously on the floor of the Pacific ocean, nestled in the crevices of hydrothermal vents that spew boiling, mineral-laden water into the chilly sea. Then, in 1982, a small submersible named *Alvin* dived down two miles to their homes and ferried samples of the organism to the surface.

This week, scientists announced that they have finished sequencing all the genes of the deep-sea microbe, a crucial step in comprehending how the unusual microorganisms, known as *Methanococcus jannaschii*, flourish without using sunlight, oxygen, or any surrounding organic material.

"We're trying to describe the entire life of an organism based on what's in its genome," says J. Craig Venter of The Institute for Genomic Research (TIGR) in Rockville, Md. "There are literally more than a thousand genes that we have no idea what they do. They've never been seen before in biology."

TIGR



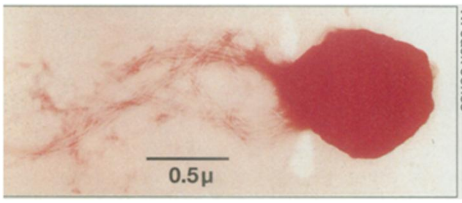
The tree of life appears to have three main branches: Bacteria, Archaea, and Eucarya. Scientists are still debating the exact patterns of the limbs and twigs.

Beyond answering questions of basic biology, these novel microbial genes may inspire practical spin-offs, such as industrial enzymes that work at high temperatures or genetically engineered organisms that make methane, an alternative to fossil fuels.

The newly identified genes should also help unravel the mystery of the Archaea. This group of microscopic organisms, which includes *M. jannaschii,* shares similarities with bacteria but may be more closely related to plants and animals, say some scientists.

Until recently, biologists had divided the so-called tree of life into two main branches, the Bacteria (or Prokaryotes), and the Eucarya (or Eukaryotes). Among other dissimilarities, eucarya, which include fungi, plants, and animals, house their DNA in an intracellular sac called the nucleus while bacteria do not.

In 1977, Carl R. Woese of the University of Illinois at Urbana-Champaign shook this tree of life when he declared that several known microorganisms deserve a branch of their own (SN: 11/12/77, p. 310). The microbes, originally labeled archaebacteria by Woese and now called archaea, do not have nuclei but differ significantly from most bacteria in many other ways.



W. Jack Jones

Colorized micrograph of M. jannaschii.

Scientists initially found archaea only in extreme environments such as the hydrothermal vents, the hot springs of Yellowstone National Park, and areas marked by severe acidity or salinity. More recently, however, investigators have discovered abundant archaea all around them. "It shows how little we know about life on this planet. This group of organisms could represent more than 50 percent of the earth's biomass," says Venter.

Over the last few years, Venter and his TIGR colleagues have pioneered a novel strategy to quickly sequence genomes and have proved the method effective with the sequencing of the first two bacterial genomes (SN: 6/10/95, p. 367). In essence, they randomly chop an organism's strands of DNA into thousands of small fragments whose sequences can be quickly read. With computer software that recognizes overlapping sequences among the fragments, the researchers then piece together the complete genome.

Applying this strategy to *M. jannaschii* revealed 1,738 putative genes, only 44 percent of which resemble genes from other organisms, report Carol J. Bult of TIGR, Venter, Woese, and their colleagues in the Aug. 23 SCIENCE.

The genes presumed to play a role in *M. jannaschii's* metabolism largely resemble bacterial genes. Those genes greatly interest investigators because *M. jannaschii* is the first autotroph whose genome has been sequenced.

Autotrophs, unlike animals, do not depend upon amino acids and organic molecules from their environment. *M. jannaschii* "makes everything it needs from carbon dioxide, nitrogen, and hydrogen," says Venter.

Understanding how and when autotrophs evolved may topple the popular idea that life originated in a primordial pool rich in amino acids and organic molecules. "That theory has been challenged, especially in recent years, by scientists, including myself, who believe life began in an autotrophic way," says Woese.

While *M. jannaschii's* metabolic genes mirror those of bacteria, other of its genes match those of eucarya. Proteins from these genes appear to translate DNA into RNA, assemble proteins, and copy the microbial DNA.

This initial look at *M. jannaschii's* genome seems to support Woese's long-held theory that archaea are more closely related to eucarya than to bacteria. Yet some investigators caution that a definitive conclusion will demand a much more rigorous genome analysis and the sequencing of other genomes.

"Until now, we've been making huge extrapolations from minimal data. The picture won't be complete from a small sampling of genomes, however. It is going to require 50 to 100 genomes, of organisms that are widely distributed throughout the universal tree of life, to really have a sense of what happened in our evolutionary history," says Mitch Sogin of the Marine Biological Laboratory in Woods Hole, Mass.

For example, Woese expects the sequencing of a second archaea genome, scheduled for completion this year, to allow scientists to discern how many of the novel genes in this first genome are shared by other archaea. —*J. Travis*