Introduction: Archaeans and other thermophiles

Archaea are prokaryotic (some were known, but were believed to be bacteria before Woese) and are distinct from Eukarya, Eubacteria
- cell wall structure and chemistry
- lipid bilayers (aliphatic HC–ester bond–glycerol, not phospholipid)
- metabolism

Show great physiological, morphological, and reproductive diversity
- reproduce by binary fission or budding
- respiration: some obligate aerobes/anaerobes, some facultatively anaerobic
- nutrition: some autotrophic by chemosynthesis—use inorganic compounds to manufacture organic

Many tend to prefer high-temperature, hypersaline, anaerobic environments. (What does "high-temperature" mean? Many archaeans can live at temperatures above 80 C. Others prefer environments such as undersea thermal vents, which can have temperatures well over the boiling point of water.)

(Other oddities: methanogens found in animal digestive tracts, swamps, sewers)

But not all thermophiles are archaeans. Some photosynthetic cyanobacteria thrive at high temperatures. And one thermophilic organism of great scientific and technological interest, Thermus aquaticus, belongs to the eubacteria.

**Thermus aquaticus**

T. aquaticus is a species of thermophilic bacterium discovered in 1969 by Thomas Brock and Hudson Freeze of Indiana. They originally isolated it from the Lower Geyser Basin, a hot spring in Yellowstone National Park. It has since been found in thermal habitats around the world. Optimum temperature around 70 C (158 F), but can survive in range of 50–80 C (122–176 F).

In many places, where the temperature also permits cyanobacteria to thrive, T. aquaticus can live in association with them, deriving its energy from their photosynthesis.

If it's too hot for photosynthetic bacteria, T. aquaticus can absorb organic material directly from the water in which it lives. (It also lives in hot water heaters like the one in your home.)
Thermophiles, thermostable enzymes, and PCR

One of the reasons scientists were puzzled by the discovery of life at high temperatures had to do with biochemistry.

Thermal equilibrium. You--37 C. Parakeet--40 C. Ectotherms--broad range. But in general vertebrates don't much like to go over 40, and arthropods and plants over 50.

One of the things that happens when temperatures get too high is that proteins denature—they don't fold properly and thus don't work as they're supposed to. Remember that all enzymes are proteins, and that some enzymes (including nucleases, polymerases, ligases, and helicases) are essential for the replication, transcription, and translation of DNA and RNA.

So how do thermophilic organisms manage to live and reproduce?

It turns out that they have their own versions of these enzymes that are specially equipped to work at high temperatures. In 1976, Chien, Edgar, and Trela isolated a DNA polymerase from *T. aquaticus*, and found that it had a temperature optimum of 80 C. (Compare this to the 37 C optimum of most nucleic acid polymerases.)

This was an interesting object of scientific study, but in the early 80s it became something more. Kary Mullis, a biochemist working for a company called Cetus, was developing methods for genetic screening—one big problem was that for most available screening methods, you needed many copies of the DNA sequence you were looking for.

Mullis had an idea that, if you used the right enzymes combined with a cycle of high and low temperatures, you could "amplify" a sequence of DNA from only a few copies to hundreds of millions. This is called the polymerase chain reaction technique (PCR).

There was one problem: Every time you heated the DNA to separate the strands, you denatured all your polymerase enzyme, so new enzyme had to be added for the next round. This was a pain.

Mullis realized that "Taq polymerase" (the DNA polymerase from *T. aquaticus*) was the answer: it was stable at high temperature, and could be used to make PCR vastly more affordable. (Roche bought the PCR patents from Cetus for $300 million. Mullis got $10,000...and a Nobel prize.)
SOURCES

http://en.wikipedia.org/wiki/Archaea

http://en.wikipedia.org/wiki/Thermus_aquaticus

http://www.bact.wisc.edu/Bact303/b27

