Chapter Five

Thermophiles

Not all microbes are refined enough to relish a dinner of human turds, but many do. Perhaps the most mysterious and the most impressive are the *thermophiles*, or heat lovers.

Bacteria are generally divided into three classes based on the temperatures at which they best thrive. The low-temperature bacteria are the *psychrophiles*, whose optimum temperature is 59°F (15°C) or lower.[1] The *mesophiles* live at medium temperatures between 68° and 113°F (20° and 45°C). *Thermophiles* thrive above 113°F, and some live at, or even above, the boiling point of water.[2]

Back in the 1930s, scientists found that thermophiles included the *streptococci, the lactobacilli, the colon group, anaerobic, and especially aerobic spore-forming rods.* It was those spore-forming rod bacteria that concerned scientists because they were found in pasteurized milk. The heat of pasteurization wasn't killing them; if anything, they thrived in it. Scientists were finding thermophiles in milk, cow manure, soil, dust, leaves of plants, and even the surface of any exposed material.[3]

If you want to do an experiment of your own, the next time you have a tree ground up by a chipper-shredder machine, pile the tree particles in a nice heap and stick a compost thermometer in it. You will find that within about seventy-two hours, the internal temperature of the ground-up tree will be 120°or 130°F (49° or 54°C), if the pile is big enough. The heat is from the thermophilic bacteria. They like a hot environment and will create one when given a chance. But why are they there in the first place? Where do they come from?

A notable thermophile is the *Geobacillus*, formerly named *Bacillus stearothermophilus*. It's an aerobic, rod-shaped bacterium that forms spores. Its temperature range for growth can be as low as 95° or as high as 176°F (35° or 80°C), but temperatures between about 113° and 158°F (45° and 70°C) are normal.[4] Despite this very hot optimum temperature range, these mysterious thermophiles can be found all over the Earth, a planet with an average surface temperature between 44 and 50°F (7° and 10°C).

Thermophilic bacteria have been found on all seven continents, in the Pacific Ocean, in the Mediterranean Sea, in the Bolivian Andes at an altitude of twelve thousand feet, and even in the upper troposphere six miles high. They've been found in oil wells seven thousand feet below the ground, in gold mines ten thousand feet underground, and in the ocean over six miles below sea level.[5]

These are bacteria that love to eat human excrement, discarded organic material, and dead animals, yet their favorite hangouts are hot springs, geothermal soils, hot underground oilfields, natural gas wells, and hydrothermal vents.[6] And compost piles.

Thermophiles are not new to science. The term *thermophilic* was probably first used by Miquel in 1879 to describe organisms that grow in what should be fatally high temperatures.[7] The first accounts describing organisms that live at such high temperatures were published by Pierre Sonnerat in 1774 when he reported on fish that lived in water at a temperature of 156°F (69°C). Other researchers reported the growth of algae in a hot spring at Karlsbad at 158°F (70°C) in 1837, in another hot spring at a temperature of 208°F (98°C) in 1846, cyanobacteria in a hot geyser at 181°F (83°C) in 1866, as well as many other reports.[8]

More recently, there have been numerous reports of large numbers of thermophiles found even in cool soils and cold ocean sediments. Thermophilic bacteria were found in Iceland soils where the average temperature is 57°F (14°C), and in cool soils in Northern Ireland, the Andes, and in the northern US. The local soils in Northern Ireland never reached the bacteria's minimum growth temperatures. Scientists wonder how these thermophilic bacteria can exist in large numbers in environments where they can't grow, yet they speculate that the Earth's population of thermophiles is "enormous." Thermophilic bacteria were even found in Pacific Ocean basin cores in sediments dating back nearly six thousand years.[9]

The answer seems to lie in the ability of thermophilic bacteria to form spores. When they don't have conditions favorable for growth (i.e., high temperatures), they form "endospores," a life cycle condition that allows for their long-term survival[10] — very long term. One scientist estimated that thermophilic endospores can survive for a staggering 1.9 billion years at a temperature of 109°F (43°C), and longer if the temperatures are lower.[11] One theory suggests that the thermophiles were among the first living things on this planet, developing and evolving during the primordial birthing of the Earth when surface temperatures were quite hot. They have thus been called the *Universal Ancestor*, esti-

EARLY INVESTIGATIONS OF THERMOPHILIC BACTERIA

INVESTIGATOR	ORGANISMS	SOURCE	TEMPERATURE
Miquel (1879–88)	*Bacillus thermophilus*	Seine River water; sewage excreta; dust; air	42°–70°C. 65°–70°C. optimum
Van Tieghem (1881) Certes and Garrigou (1886)	(1) Streptococcus (2) Bacillus (1) Small rods (2) Filaments	Water in which beans had been cooked Hot spring at Luchon	Up to 74°C. Up to 77°C 45°–64°C.
Globig (1888)	Many bacilli (30 kinds)	Garden soil	50°–70°C.
Burrill (1889)	Two bacilli	Silage; manure	60°–70°C.
Schloessing (1889) Cohn (1893)		Stable manure	Up to 79.5°C.
Flügge (1894)	Many bacteria	Sterile milk	24°–44°C. or 27°–54°C.
Leichman (1894)	A bacillus	Slimy milk	45°–50°C.
MacFadyen and Blaxall (1894)	Many bacilli	Earth, river + sea water, river mud, air dust, straw and feces of men, mice and chickens	60°–65°C.
Gorini (1895)		Milk	37°–
Karlinski (1895)	(1) *Bacillus Illidzensis capsulatus* (2) *Bacterium Ludwigi*	Hot springs of Illidze in Bosnia	50°–58°C. 55°–57°C.
Rabinowitsch (1895)	Eight species of thermophilic bacteria	Many sources; widely distributed in nature	34°–75°C.
Weber (1895)	Bacillus I Bacillus II Bacillus III	"Sterile" milk	22°–60°C. 22°–60°C. 30°–65°C.

Source: Morison, Lethe E., and Tanner, Fred M. (1921). Studies on Thermophilic Bacteria: Aerobic Thermophilic Bacteria from Water. Dept. of Bacteriology, Univ. of Illinois Urbana.

mated at 3.6 billion years old. Thermophiles could therefore be the common ancestral organism of all life-forms on our planet.[12]

Thermophilic bacteria obviously have evolved to decompose organic material, almost like the Earth's janitors, or maybe Mother Earth's invisible helpers, cleaning things up as they have for eons. They work in partnership with mesophilic bacteria, which must raise the temperature of an organic mass high enough for thermophilic growth to be sparked. This is like a microbial tag team — mesophiles begin the decomposition of organic material; this raises the temperature enough to waken the thermophilic spores; the work is then handed off to the thermophiles, who take over and work themselves into a fever, consuming the organic material, be what it may (turds, garbage, dead animals), and converting it back into, well, Mother Earth. In the process, if there happen to be human pathogens lurking in the organic material (think shit), they're no match for the thermophiles. A steaming mass of organic material being eaten by thermophiles is hell on Earth for human disease organisms. And that's exactly where disease organisms should go to die, for die they will.

Mother Earth has some tricks up her sleeves, too. On every square meter of her surface, she is releasing fifty to over two hundred bacteria per second. These can be uplifted by the wind, where they can remain aloft for two to fifteen days before settling back to Earth. That's probably why some thermophiles have been found way up in the troposphere. Add massive wind events such as desert dust storms, which can move a billion tons of soil a year, and bacteria can cross the entire Atlantic Ocean in just three to five days and the Pacific Ocean in a week to ten days. Thermophilic spores are hardened to survive. They're resistant to ultra-violet light, desiccation, and extreme temperatures, conditions that will kill most bacteria.[13] So Mother Earth scatters them around the globe as microscopic spores, a form that is unbelievably durable and long-lasting. They settle back to the Earth and wait patiently, even a billion years if necessary, to be sparked back to life. They're Mother Nature's servants, patiently waiting to serve *us*.