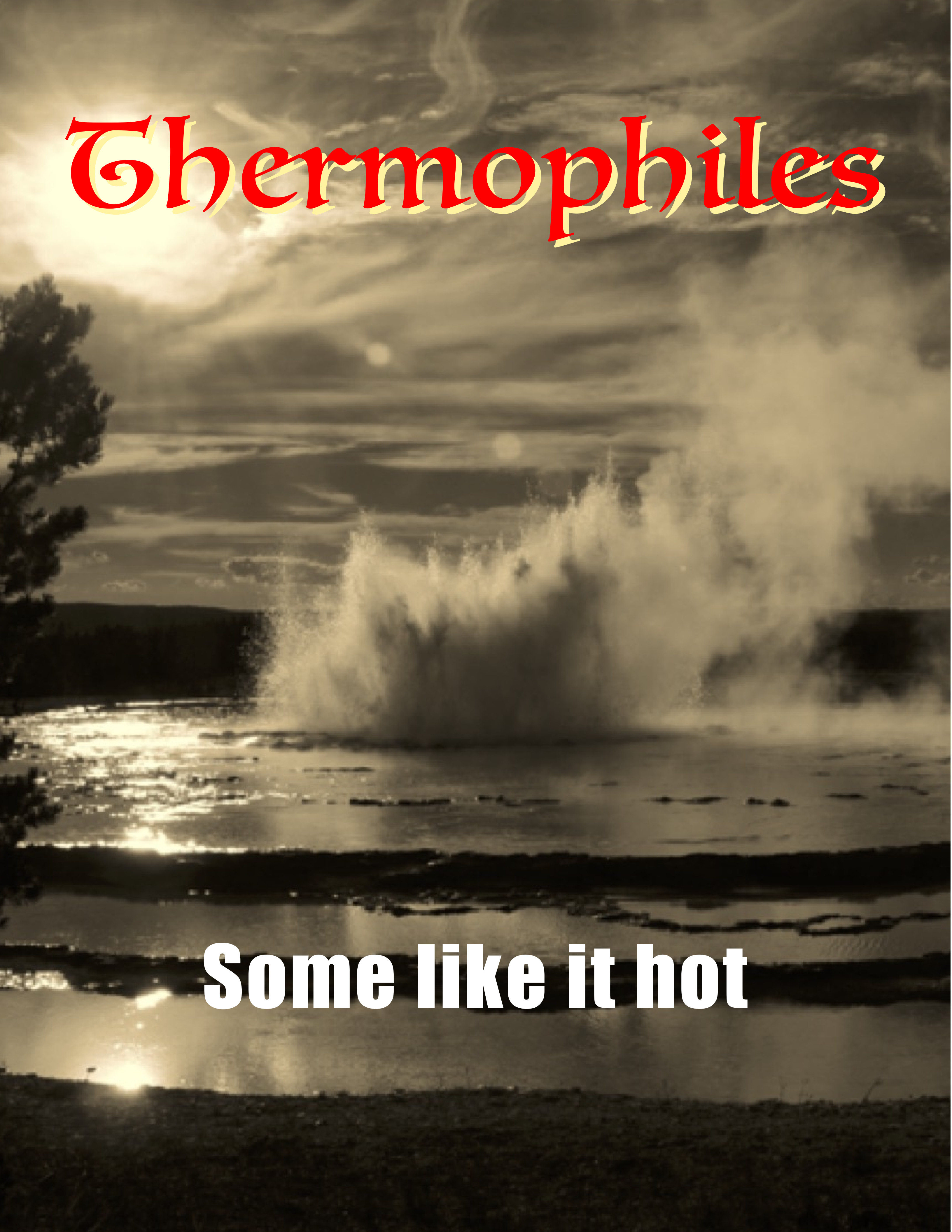
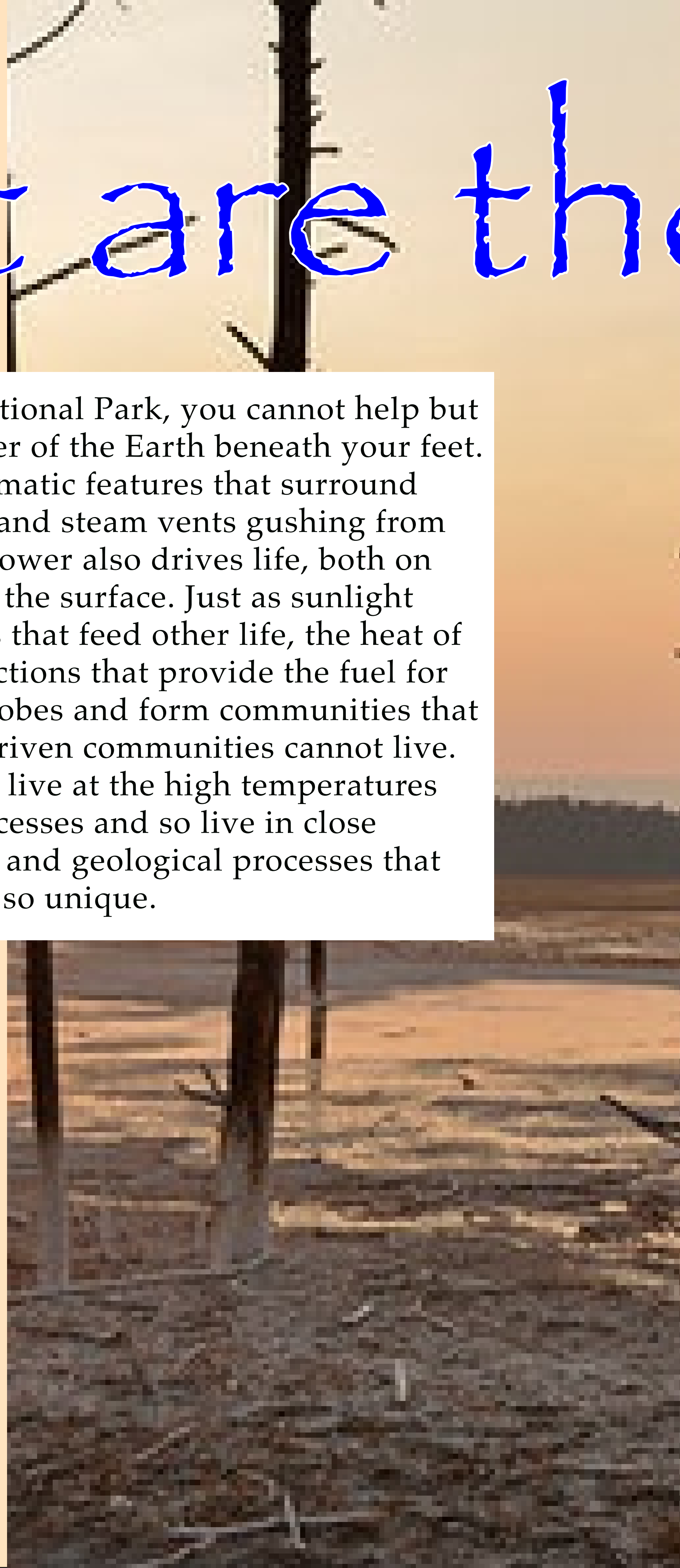
Thermophiles



Some like it hot

What are th

If you visit Yellowstone National Park, you cannot help but be moved by feeling the power of the Earth beneath your feet. That power drives all the dramatic features that surround you, the geysers, hot springs and steam vents gushing from deep within the Earth. That power also drives life, both on the surface and deep beneath the surface. Just as sunlight provides the power for plants that feed other life, the heat of the Earth drives chemical reactions that provide the fuel for microbes that feed other microbes and form communities that live in places that the plant-driven communities cannot live. Those microbial communities live at the high temperatures that drive those chemical processes and so live in close association with the chemical and geological processes that make places like Yellowstone so unique.



ermophiles?

Microorganisms that must live at temperatures higher than our body temperature (98.6°F or 37°C) are called thermophiles or "heat-loving" microbes. Those that live at the highest temperatures are called extreme thermophiles or hyperthermophiles. The highest temperature that we know a microbe can live is 121°C, the temperature inside a pressure cooker. At sea level, water boils at 212°F (100°C).

Yellowstone hot

The thermophilic microbes at Yellowstone live in the hot springs and the walls of geyser vents. Since Yellowstone is 8,000 feet (2,400 meters) above sea level, the water at the source of the hot springs, where the water first comes out of the ground, boils at 198°F (92°C). Consequently, only a limited number of kinds of thermophiles can live at these sources.

Many of the thermophiles that grow in the sources of the springs grow on the gasses that are dissolved in the water. These gasses come from the chemical processes occurring underground. Carbon dioxide, hydrogen, and hydrogen sulfide are the major gasses used by these microbes. These microbes are like the green plants we live with in that they use carbon dioxide to make all the complex carbon-containing compounds that make up living cells. Green plants use the energy of light to "fix" carbon dioxide into these compounds, but these

spring microbes

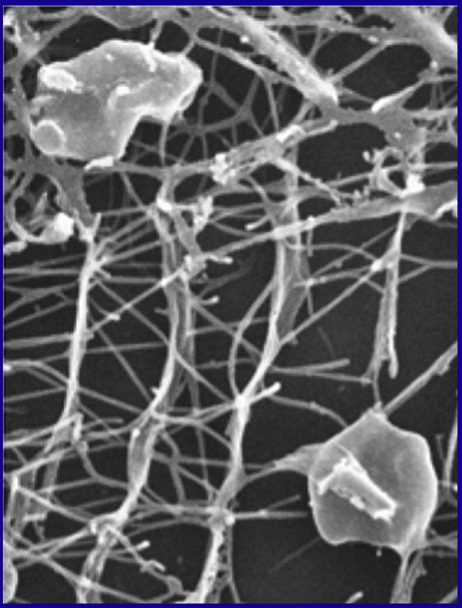
microbes use hydrogen or hydrogen sulfide gas as their source of energy. Once they have made these larger carbon compounds, those are released after these cells die and they can then be used by other kinds of microbes as their food source, just like we eat green plants for ours.

There are many different temperatures in the waters at high temperature ("geothermal") sites like Yellowstone. As the spring water flows away from the source, it cools, so you get a gradient of temperatures in the outflow streams. At Yellowstone, the most dramatic example of this is the Grand Prismatic Spring (see photo, right), the largest hot spring in the park. Streams flowing out of the spring are multicolored.

The source of the Grand Prismatic Spring is deep blue because the water contains suspended particles of silicate minerals. These bend the sunlight that reflects off the water so that only light at the blue end of the spectrum hits our eyes. This is similar to the process that makes the sky blue. The edge of the spring is yellow and orange because the bacteria that live in this slightly cooler water use sunlight for energy. They use different parts of the sunlight, so they are a different color than green plants. While green plants use red light (so they appear the complimentary color, green), these bacteria use blue to green light, so they appear orange. Microorganisms that use light are called phototrops, or "light-eating," microbes. These orange phototrophs grow in the upper regions of the outflow streams, too. Further downstream, as the water cools more, green phototrophic bacteria predominate (see photo above).

Deep sea hydrothermal vent microbes

Features like those found at Yellowstone National Park can be found at the bottom of the deepest parts of the oceans. The surface crust of the Earth, including the sea floor, is composed of plates of rock that slide over the underlying mantle layer. These plates can pull apart at “spreading centers” or slip under one another where plates collide. At both types of sites, hot magma can come close to the surface or even break through forming volcanoes. Where this happens undersea, cold sea water sinking through deep sediments comes into contact with heat rock rising from underneath. The water is heated to temperatures far above the boiling temperature on the surface because the pressure from the overlying water is so high. This hot water rises and brings gasses from below along with dissolved metals. When it reaches the cold seawater, it can erupt violently as underwater geysers called black smokers (see photo above). The “smoke” is actually dissolved minerals in the rising hot fluid that form larger particles when the fluid is rapidly cooled. These minerals can accumulate and form porous chimneys through which the hot fluids both erupt from the top and seep through the sides. These fluids can be 350°C (662°F), far too hot to support life. The fluids cool as they seep to the surface of the sides of the chimneys and contact the cold (4°C, 39°F) seawater. Like the outflow springs at Yellowstone, these cooling waters can harbor many thermophilic microbes.

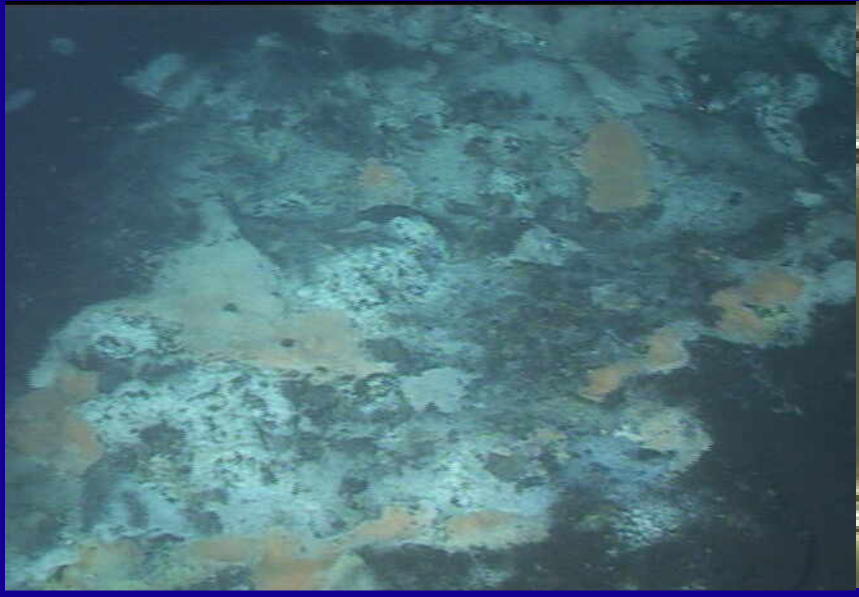


Pyrodictium disk-shaped cells connected together by thin tubes. Pyrodictium grows up to 105°C.

As in the sources of the Yellowstone hot springs, microbes living at the highest temperatures (up to 121°C, 250°F) fix the carbon dioxide in the fluids and form large organic molecules. Those are then consumed by other microbes both at these high temperatures and also in cooler fluids moving "downstream" from the source. The cooling fluid does not move through streams, but through channels in the sides of the porous chimneys.

Other kinds of bacteria live in the sediments surrounding the chimneys. Some of these use the hydrogen sulfide gas dissolved in the hot fluid that slowly rises through the sediments. These bacteria, called Beggiatoa, combine the sulfide with oxygen dissolved in the surrounding seawater to generate energy much like we use oxygen in a process called respiration. These Beggiatoa are moderate thermophiles (50°C, 122°F) and form thickwhite or orange mats of cells across the sediment surface.

Mats of Beggiatoa cells on the surface of sediments at the Guaymas Basin off the coast of Mexico. Filaments of cells of Beggiatoa are shown at right. The bright particles inside the cells are granules of elemental sulfur that tehy acumulate when they respire hydrogen sulfide.



Microbial growth in a hot water pipe.

Hot si

Thermophilic microbes do not just inhabit exotic locales. They can be isolated from most soils and waters because some form spores that are a resting form. They may not grow in the cooler environments, but their spores can persist for long periods without growing.

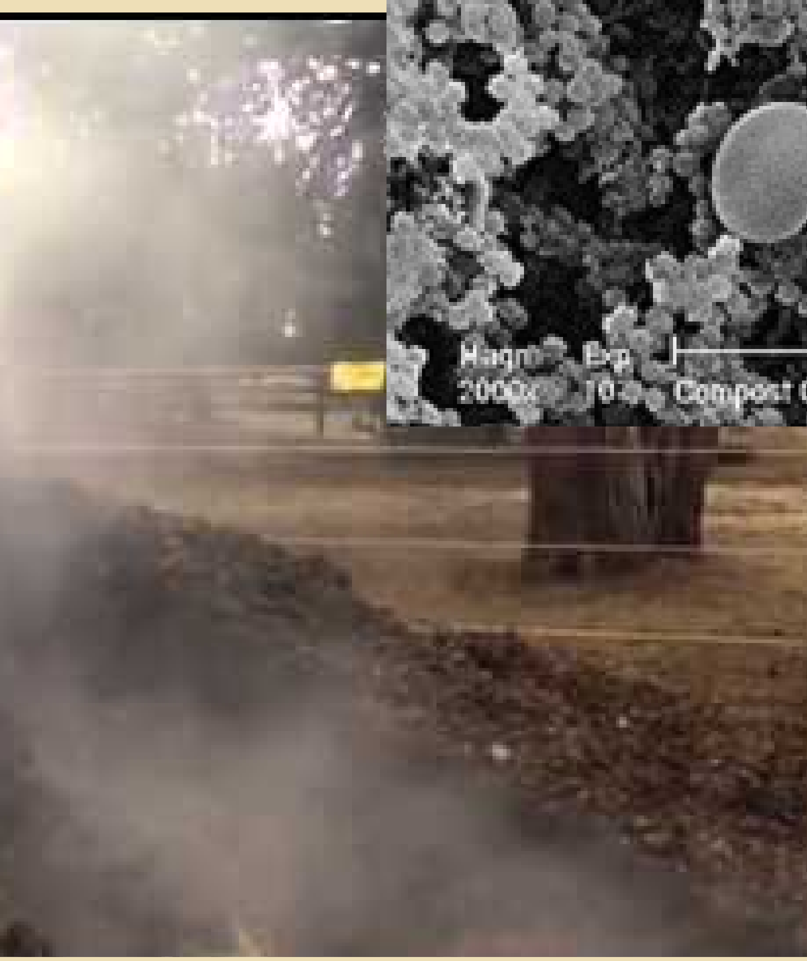
There are several hot environments that one might encounter. Thermophiles have been isolated from domestic hot water heaters. They live in films attached to surfaces inside hot water heaters and pipes. They are harmless to humans and usually do not grow enough to cause problems.

Thermophiles are also found in compost piles. A well-maintained compost pile that is frequently turned to allow air to enter the pile will heat up because of the rapid rate of microbe-mediated decomposition of the plant materials. The temperature can rise to 70°C (158°F). Thermophilic microbes work in these piles to decompose the plant wastes. You can fell the heat the microbes generate. It is also apparent if the air is cool because

tes near you

you might see what looks like steam rising from the pile. The pile is not hot enough to generate steam, but water does evaporate more rapidly from a heated pile and, in the cool air, the water forms small droplets and appears like steam.

Magnified compost microbes.



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https://www.ourbreathingplanet.com/mount-erebus/

Great Fountain Geyser,Yellowstone National Park, Wyoming
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Fountain Paint Pot, Yellowstone National Park, Wyoming
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Grand Prismatic Spring, Yellowstone National Park, Wynoming
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Hydrothermal vent along the Juan de Fuca Ridge
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Pyrodictium cells
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Beggiatoa mat, Guaymas Basin, Sea of Cortez
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On-line resources:

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https://www.nps.gov/yell/learn/nature/thermophilic-bacteria.htm

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