The shale riverbed
Photo: Linda Grashoff

Finding Beauty in Bacteria: Biofilms in the Vermilion River

By Linda Grashoff

Leptothrix discophora atop a pudding-like *Gallionella ferruginea* and the iron-oxide it produces

If you have spent time on or near the Vermilion River you probably have noticed something that looks like an oil slick on the surface of the water. Sometimes the rainbow-hued coating may appear on top of an orange pudding-like discharge oozing from the bank *(left)*. Besides these rather strange sights, you may have seen a grainy or wispy rust-colored deposit lying on the riverbed *(bottom right)* or a bright yellow substance coating the riverbed and surrounding rocks *(top right)*.

The Vermilion is one of the cleanest rivers in Ohio, so what's going on here? Are these pollutants that the experts have simply overlooked? No, they are not pollutants—or algae. Instead they are evidence of ancient forms of microbial life—harmless bacteria that evolved before the algae.

Long before the development of photosynthesis, the process by which plants use the sun's energy to make food, certain microorganisms acquired the ability to use certain minerals rather than sunlight to capture energy. They belong in the category of bacteria known as *chemolithotrophs*. Their name indicates that they are organisms that derive their nourishment *(troph)* by chemical means *(chemo)* from rocks *(litho)*. Neither plant nor animal, these organisms were living in this area long before glaciers created the river itself.

The chemolithotrophs that we see most often on the Vermilion interact chemically with microscopic iron embedded in the river's shale bedrock *(above)*. Some of them use sulfur and manganese also present in the river environment. None of the chemolithotrophs is harmful to the river or to other river life—with the exception of some insects and other small arthropods (like millipedes) that may become caught in thick bacterial soups *(below)*.

An iridescent coating of drying *Leptothrix discophora* on leaves and rock, bacteria-produced yellow schwertmannite beneath

If you spend a lot of time on the river, you know that you don't always see these colorful phenomena. Their conspicuousness depends on many factors. The speed of the river current is one. Water that moves swiftly doesn't allow most of these bacteria to build visible colonies. So, for example, you won't see them or their products during the spring thaw or following a summer downpour. Many of the bacteria that metabolize rock-bound iron and manganese prefer slow moving or still water cut off from the main current, perhaps by rocks or fallen tree limbs.

The temperatures of the water and air affect our ability to see the microbes. The mineral-active bacteria of the Vermilion River tolerate the full range of our local temperatures, so they remain active all year. But we seldom see them in winter *(next page, bottom)* because they are less numerous then; warmer conditions foster faster, hence more visible, bacterial growth. Seeping groundwater also plays an important role in the growth of these ancient bacteria. It is only when river water mingles with groundwater seeping from the bank *(next page, top left)* that the bacteria form their most robust colonies.

Moving sideways or crouching down to change the angle of the sun relative to your eyes can make a previously invisible biofilm visible. Light intensity also matters. Sometimes a *Leptothrix discophora*

Granular-looking red-orange iron oxide on the riverbed, possibly formed by the iron-oxidizing bacterium *Toxothrix trichogenes*

Millipede caught in a dehydrating *Leptothrix discophora* film

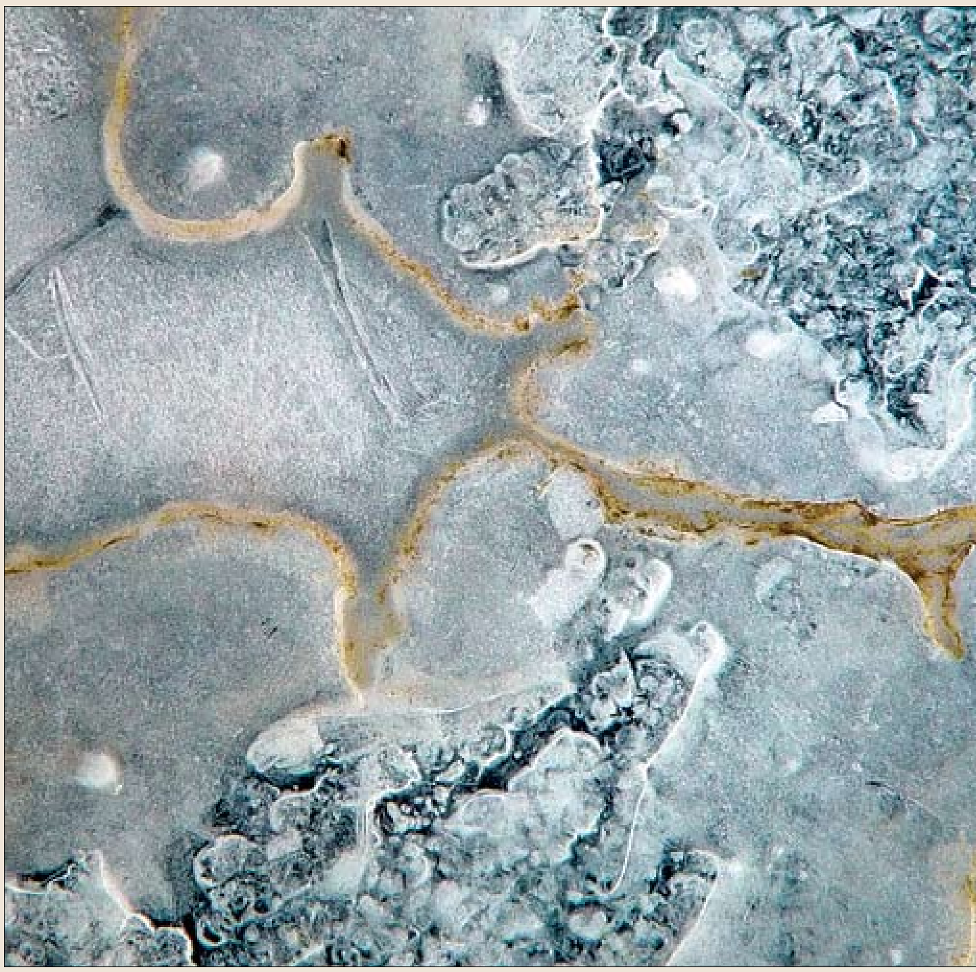
A *Leptothrix discophora* film beginning to grow near the riverbank where groundwater is discharging

biofilm (the one that looks like an oil slick) cannot be seen in bright overhead sunlight, but a shadow cast over the colony may reveal its presence. During a drought, when river flow is reduced to a trickle, iron oxide—evidence of bacterial action—may still be present in the dry parts of the riverbed *(right)*. But even when all visible evidence is absent, these chemolithotrophs are always present. Only when conditions favor their growth do they multiply to visible densities.

Mineral-active bacteria like those found on the Vermilion occur around the globe. Some authorities say that chemolithotrophs like those in our river are not only harmless, but are actually essential to many other forms of life, including humans. These scientists maintain that if bacteria did not release iron and manganese from geologic materials, too little of these elements would be available in the dissolved forms needed by plants and animals as nutrients.

Leptothrix discophora: The Rainbow on the River

Leptothrix discophora is the bacterium that makes the rainbow film some of us may confuse with an oil slick. An easy way to determine whether a film is oil or bacteria is to run a stick through it. If it is *L. discophora*, the film will break up and stay that way. If oil, it will flow back together immediately. Some of this *L. discophora* film is intact, and some is broken into platelets. Wind, insects, and other animals can break the film easily.



January river ice encasing manganese biofilm

Bacteria-produced iron oxide on the dry riverbed

Scientists have even developed ways of harnessing the actions of these bacteria for human uses. Some mineral-active bacteria help remediate oil spills and acid-mine drainage. Iron- and sulfur-active bacteria of the genus *Thiobacillus* have been used in industry to extract copper, silver, zinc, nickel, uranium, and gold, among other elements, from low-grade ore. They do so by oxidizing the metals, in the process accumulating them into batches of a size that can be more easily handled. The method is the cheapest available in the short run and is cleaner for the environment than other methods of extraction.

Besides their practical uses, chemolithotrophs provide opportunities for endless scientific investigation and—perhaps especially on the Vermilion River—contemplation of their natural beauty.

Henrietta Township resident Linda Grashoff gets as close to the Vermilion River as often as she can, usually stalking the same stretch of shore. Now a full-time artist, Grashoff retired as an editor from Oberlin College. She is writing a book about iron-active bacteria that will include her photographs of these microbes on the Vermilion River. Grashoff maintains studio space and sells her work at the Ginko Gallery and Studio in Oberlin.

All in the Way You Look at It

The angle of the sun relative to the position of a viewer's eye or camera lens influences the appearance of a *Leptothrix discophora* biofilm, the film that resembles an oil slick. Look at a spot with the sun on your back, and all you may notice is still water and perhaps a rusty deposit on the riverbed. But move to the other side of that patch of water, facing the sun, and you may see a light-blue metallic film or what looks like a rainbow on the water's surface. These photos show the same spot on the river from two different angles.