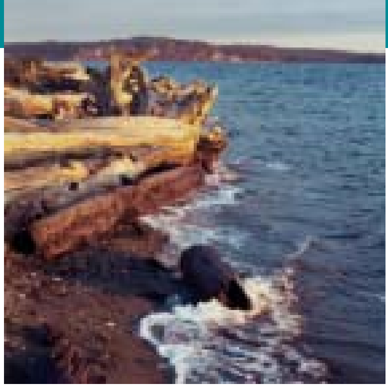
ENVIRONMENT



The Promise of Bioremediation

Tiny microbes may help clean up industrial-sized messes

Bacteria will eat almost anything. Pick a substance, from sewage to paint chips, and there is a good chance of finding a microbe that dines on it.

This is good news for Puget Sound, where a number of toxic contaminants are threatening the health of the marine environment. Here, researchers are studying the microbes that munch on hydrocarbons, substances found in oil and industrial wastes.

"The neat thing about this is that the bacteria are naturally there," says James Staley, a microbiologist at the University of Washington. "Bacteria are, in effect, cleaning up Puget Sound," he says.

But they need a little help. The small concentrations of these microbes that naturally occur in the oceans are not enough to gobble up major messes like oil spills or high concentrations of waste. Scientists that study bioremediation, the technology that uses these microbes to break down toxic products, are looking for ways to step up the activities of these microbes.

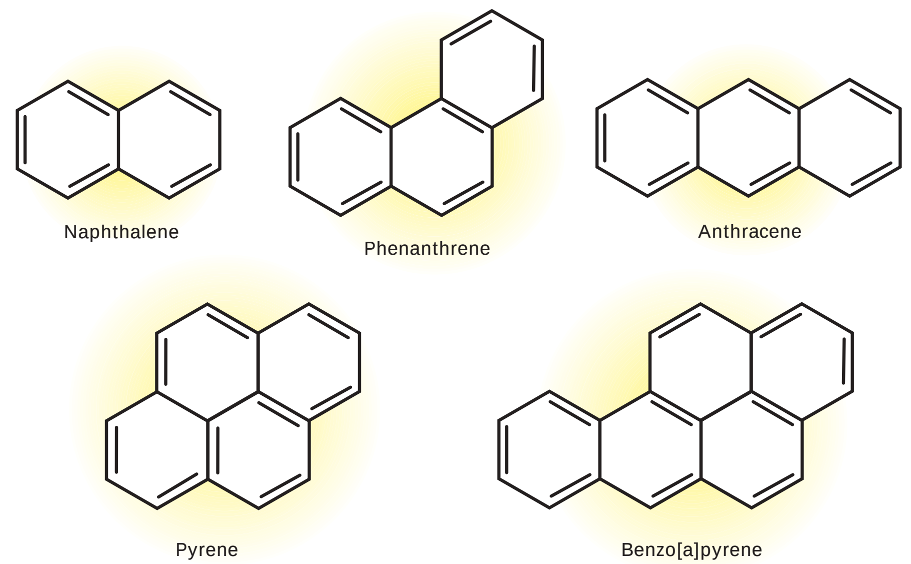
With funding from the Washington Sea Grant Program, Staley is focusing his efforts on the former site of Wyckoff wood-preserving facility in Eagle Harbor on Bainbridge Island in Puget Sound. When it was in operation, the plant treated wooden pilings with creosote, a substance that contains polycyclic aromatic hydrocarbons (PAHs). Discharge and spills from the plant led to high levels of PAH contamination in Eagle Harbor, prompting the EPA to declare it a Superfund site in 1994.

These contaminants pose a problem for the local wildlife, since some of these compounds are carcinogenic. The heavy PAH particles tend to sink, accumulating in the bottom sediments. When bottom-feeding fish are exposed, these compounds build up in their tissues. Eventually, the toxins work their way up the food chain, affecting the fish that we eat.

Oil and water on pavement.

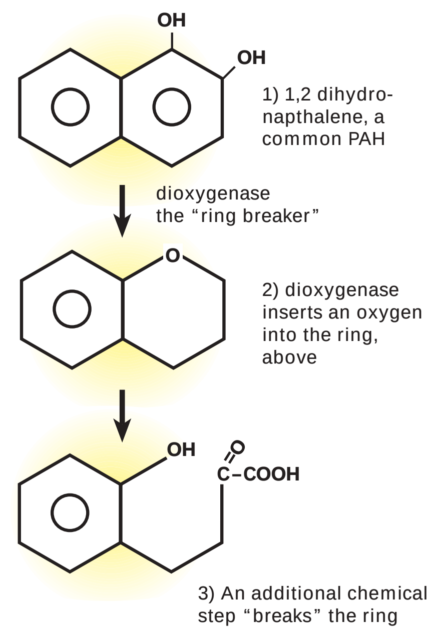
Photo: Laura Carsten

by Laura Carsten



Polycyclic aromatic hydrocarbons are difficult for bacteria to break down because of their stable ring structure. Linear chains of rings, like naphthalene are easier to break apart, while stacked configurations, such as pyrene, are more difficult.

Naphthalene degradation



The dioxygenase enzyme in *Cycloclasticus* inserts an oxygen into the ring of carbons, breaking it apart.

For bacteria, however, these carcinogenic compounds are an attractive source of food—if they have the ability to digest it. Staley has intensively studied the sediments in Eagle Harbor, trying to sort out which bacteria succeed at this, and how they do it.

Brian Hedlund, a former student of Staley's, aboard the *Clifford Barnes*, sampling for PAH-degrading bacteria.

PAHs are a diverse group of chemicals, but they all have one thing in common: their ring-like shape. When six carbon molecules get together, they often form ring structures, the most stable configuration. This stability makes the rings very hard to break down.

But one species of bacteria, dubbed *Cycloclasticus pugetii*, Latin for "ring breaker from Puget Sound," has got this process down pat. It has a special enzyme called dioxygenase, which inserts an oxygen into the ring, breaking it apart for easy digestion. Without this enzyme, the bacteria wouldn't be able to break down the PAH compounds.

Staley has discovered that *Cycloclasticus* is a specialist, preferring to dine only on PAHs. Because of this, the gene that codes for the ring-breaking enzyme is probably a stable trait for this species, he says. But he suspects that *Cycloclasticus* has donated this trait to other, less specialized bacteria.

Bacteria swap genes with surprising regularity. When two meet, they often exchange small chunks of DNA called plasmids. In the human gut, for instance, people develop antibiotic resistance because susceptible bacteria can get antibiotic resistance plasmids from resistant bacteria.

In the same way, Staley thinks that *Cycloclasticus* has shared the wealth of the ring-breaking enzyme with other species. In a contaminated site like Eagle Harbor, says Staley, "It would be to their benefit to pick up these genes."

The species that can successfully degrade these compounds are diverse, forming communities that can break down many types of hydrocarbons. "There are hundreds or even thousands of these compounds," says Russell Herwig, a professor of aquatic and fishery sciences at the University of Washington. "There is no one organism capable of degrading all hydrocarbons, so you need a group of different organisms to degrade contaminants."

Herwig's work with these bacteria has shown him that breaking down contaminants can be a long, slow process in nature, especially if the contaminated site lacks oxygen. But, he says, adding nutrients to the sites could speed this process considerably.

Just as humans need vitamins and trace minerals to thrive, bacteria need nutrients like phosphorus and nitrogen. Hydrocarbons do not provide a very balanced diet for these microbes, explains Herwig. They are rich in carbon and hydrogen, but lack other es-

Drop by Drop, Oil and Other Chemicals Threaten Natural Resources

On March 24, 1989, the Exxon Valdez ran aground on Bligh Reef in Alaska, spewing 11 million gallons of oil into Prince William Sound, soaking beaches, birds, and other wildlife in the process.

More than 10 years later, in spite of cleanup efforts, the ecosystem has still not fully recovered, although much progress has been made.

Such catastrophic oil spills command a great deal of public attention, yet marine systems often suffer from more mediocre types of pollution.

"In every day life, cars are dripping oil," says Russ Herwig, a scientist at the University of Washington. And when a storm comes along, these drippings are washed into storm drains, which may flow directly into lakes, streams, and the ocean.

Although the flow from a single car doesn't amount to much, the cumulative effect from many cars can add up to a lot of oil.

"Think of the thousands of cars that are around Seattle," says Herwig. "Where the cars are parked, there's a dark spot. That dark spot is caused by drippings."

Other contributors to marine pollution include the dumping of chemicals, antifreeze, paints, and used motor oil directly into storm drains. The Seattle Aquarium estimates that about two million gallons of oil ends up in Puget Sound each year.

Herwig hopes that awareness of the problem will help correct it. "Everybody, in their own little way, can certainly do things to make improvements."

Photo: Laura Carsten

sentials for bacterial growth.

In practice, researchers could provide these nutrients by adding fertilizer to contaminated sediments or beaches. However, says Staley, this could be a risky business if not done in moderation. For instance, large additions of nitrogen to marine sites could cause harmful algal blooms, and disrupt the recovering system even more. The best strategy, he believes, would be to add small, localized amounts of nutrients that would enhance the bacterial growth, preventing disturbance to the system.

With further study, the researchers believe that bioremediation could be a viable alternative to current treatment methods, such as dredging and capping. Capping, or covering the contaminated sediment with clean sediment, simply covers up the problem, while dredging out the contaminants creates havoc for bottom dwelling ocean life. Before bioremediation can become widely practiced, though, researchers need to learn more about the bacteria involved. ■

Laura Carsten recently received a master's degree in technical communication with an emphasis in science writing at the University of Washington. She has a master's degree in plant pathology and formerly worked as a research associate at Montana State University-Bozeman.