Bioremediation—Bacteria Clean Up Pollution*

Although many bacteria have dietary requirements similar to ours— that's why they cause food spoilage—others metabolize (or chemically process) substances that are toxic to most plants and animals: heavy metals, sulfur, nitrogen gas, petroleum, and mercury. Bacteria that can degrade many pollutants are naturally present in soil and water but in such small numbers that they cannot deal with large-scale contamination efficiently. Scientists are now working to improve the efficiency of natural pollution fighters. Using bacteria to degrade pollutants is called *bioremediation.*

One of the most promising successes for bioremediation occurred on an Alaskan beach following the *Exxon Valdez* oil spill. Several naturally occurring *Pseudomonas* bacteria are able to degrade oil for their carbon and energy requirements. In the presence of air, they remove two carbon atoms at a time from a large petroleum molecule (see the figure).

The bacteria degrade the oil too slowly to clean up an oil spill. However, scientists hit on a very simple way to speed up the process—with no need for recombinant DNA. They simply dumped ordinary nitrogen and phosphorus plant fertilizers (bioenhancers) onto a test beach. The number of oil-degrading bacteria increased compared with that on unfertilized control beaches, and oil was quickly cleared from the test beach.

Another group of bacteria is being investigated for its ability to clean up mercury contamination. Mercury is present in such common substances as discarded paint and fluorescent bulbs and can leach into soil and water from garbage dumps. *Desulfovibrio desulfuricans* bacteria actually make the mercury more dangerous by adding a methyl group, converting it into highly toxic methyl mercury. Methyl mercury in ponds or marshes sticks to small organisms such as plankton, which are eaten by larger organisms, which in turn are eaten by fish. Fish and human poisonings have been attributed to the ingestion of methyl mercury.

However, other bacteria, such as species of *Pseudomonas,* may offer the solution. To avoid mercury poisoning, these bacteria first convert methyl mercury to mercuric ion:

$$\underset{\text{Methyl mercury}}{CH_4Hg} \rightarrow \underset{\text{Methane}}{CH_4} + \underset{\text{Mercuric ion}}{Hg^{2+}}$$

Many bacteria can then convert the positively charged mercuric ion to the relatively harmless elemental form by adding electrons, which they take from hydrogen atoms:

$$\underset{\text{Mercuric ion}}{Hg^{2+}} + \underset{\text{Hydrogen atoms}}{2H} \rightarrow \underset{\text{Elemental mercury}}{Hg} + \underset{\text{Hydrogen ions}}{H^+}$$

Unlike some forms of environmental cleanup, in which dangerous substances are removed from one place only to be dumped in another, bacterial cleanup eliminates the toxic substance and often returns a harmless or useful substance to the environment.

Questions

1. How could oil-degrading bacteria be used commercially in a detergent or drain cleaner?
2. The bioremediation process shown in the photograph is used to remove benzene and other hydrocarbons from soil contaminated by petroleum. The pipes are used to add nitrates, phosphates, oxygen, or water. How would you modify this to remediate water pollution?

* G. Tortora, B. Funke, C. Case. 2010. *Microbiology: An Introduction*. San Francisco: Benjamin Cummings.