Eliminating Rabies Among Wild Raccoons
Cleaning Up Oil & Gas With Microbes
Helping Short Children Grow

EXPERIMENT
Isolating DNA from onions
This booklet is the first in a series that describes the application of biotechnology to problems facing Our World. We hope that you find it an interesting way to see how science and engineering are applied.

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Biotechnology is not as new a science as you might think. Biotechnology is when people use micro-organisms or cells to change one thing into another. People have been using biotechnology for thousands of years whenever they use yeast—a biological organism—to turn flour and water into bread, or grapes into wine.

Biotechnology comes from two words. "Bio" from biology, the science of living things. And "technology," the tools and techniques that can be used to change or guide natural processes. Modern biotechnology has its roots in the work of an Austrian monk named Gregor Mendel who studied pea plants in the 1840s. Mendel found that certain "factors" (later called genes) determined the physical traits of different pea plants. These traits were passed on from one generation to the next. It took scientists more than 25 years to accept Mendel's basic principles of heredity.

Once they understood these principles, scientists quickly applied them to plant and animal breeding, growing bigger flowers with brighter colors, breeding cows that produced more milk, and making golf courses with greener greens.

People did not really understand why plant and animal breeding worked until 1953. That year, James Watson and Francis Crick of Cambridge University in England determined the structure of DNA (deoxyribonucleic acid). Watson and Crick showed that DNA is a long, coiled chain of very small molecules. The arrangement of these molecules and their chemical activity are what determine cell growth and differentiation. A gene is a piece of DNA. Each gene carries instructions for cells to produce proteins that carry out specific functions. It's because of DNA that liver cells are different from skin cells and hands are different from feet.

The modern biotechnology revolution began in 1973 when Stanley Cohen of Stanford University and Herbert Boyer of the University of California at San Francisco developed a technique called recombinant DNA, or genetic engineering. This technique involves taking some of the genetic material (DNA) from one type of cell and inserting, or splicing, it into another cell (usually a bacterium). Once there, the DNA gives the same instructions to the new cell that it would have given to the cell it came from.

By using techniques like recombinant DNA, we can now speed up the rate at which we find new treatments for diseases like cancer and diabetes. Inserting new DNA can change the function of a cell. People have diabetes because the cells in their pancreas do not produce enough insulin, which regulates the level of sugar in their blood. Scientists have clipped out the piece of DNA that instructs the human pancreas to create insulin, and inserted it into bacterial cells. In this way, they turn the bacteria into tiny insulin factories. The insulin can then be harvested, purified and used as a treatment for diabetes.

Biotechnology has advanced rapidly in laboratories around the world and a variety of products of this technology are currently available or under development. But the introduction of new products using the tools of biotechnology such as recombinant DNA seems very slow. One reason is that products like recombinant human insulin costs much more to produce than the insulin commonly in use today, which is extracted from the pancreas of a pig or a cow.

Strict laws and public watchfulness also slow down the pace of biotechnology products to the marketplace. Consumer groups and lawmakers have concerns about the safety, economics, and ethics of using some biotechnology products.

In this first issue of Your World/Our World, we take a closer look at some of the ways in which biotechnology is being applied. In the first story, we see how human growth hormone, a fully-developed biotechnology product, helps patients grow. The second article describes a rabies vaccine designed to reduce the incidence of rabies in wild animals. The third article presents advances in biotechnology that may help to improve our environment.

Future issues of Your World/Our World will explore other ways that biology is being used to improve your world—the world that we all share.
It isn't easy being the shortest kid in the class. It's even harder when you are abnormally short, and you know you will never get any taller.

Some kids are extremely short because of a medical condition called dwarfism. Being a dwarf isn't cute or funny. It's a very serious and often very painful problem. Dwarfism affects as many as 15,000 kids in the United States. Other kids are extremely short because of chronic kidney failure or other medical disease.

Dwarfism and other growth problems can result if a person's body does not make enough of a natural chemical called human growth hormone. This hormone is produced by a small pea-sized tissue, called the pituitary gland, in the base of the brain.

Treatment for dwarfism, the most severe growth problem, has been available for some time. But it was quite different compared to today. Just getting the human growth hormone was hard. The U.S. National Hormone and Pituitary Program began in the 1960s to obtain human growth hormone from the pituitary glands of people who had died.

Children treated for dwarfism needed to have daily injections of human growth hormone for 6-8 years. Because of the high cost of treatments and the very limited hormone supply, not every child who needed the hormone got it.

The human growth hormone treatment helped the children to grow taller than they would have. But this treatment was stopped in the 1980s after three young adults died from a disease caused by a contaminated hormone supply.

With the advances in biotechnology, we are now able to manufacture human growth hormone. The drug supply now meets the demands of those who need it.

The results are quite rewarding! Abnormally short kids have grown much faster and have added an average of 3.8 centimeters (1.5 inches) to their predicted height. But the daily, 6-8-year treatment is still very expensive at $20,000 a year.

The process of making synthetic, or artificial, human growth hormone uses modern biotechnology methods. First, the human growth hormone gene is isolated from all the other human genes. Second, this gene is inserted into a bacteria cell. The changed bacteria can now make human growth hormone. Third, during its growth cycle, the bacteria produces a large quantity of pure human growth hormone.

New human growth hormone treats more than just small children suffering
from dwarfism or abnormally short stature. The hormone has many other uses. And scientists keep finding new ones. Human growth hormone may work as a cure for some kinds of muscle diseases. The hormone may also prevent the loss of bone mass often seen during aging.

In older adults, especially in men over 60, little or no growth hormone is produced. Researchers now believe that the lower levels of growth hormone may speed up the aging process. Injections of the synthetic growth hormone into older people in one study increased their body mass. The hormone also lowered their fat and improved the thickness of their skin. More muscle mass helps the elderly do things younger people take for granted — like walk, drive, cough, and climb stairs.

Growth hormone treatment for aging does have its limits. Growth hormone cannot help brain cells, eyes, ears, ligaments or tendons. Growth hormone won't cure getting old.

Right now scientists are busy testing other possible uses of growth hormone. People with infertility, chronic kidney problems, burns, a bone disease called osteoporosis, obesity, and loss of body mass (seen in AIDS patients, for example) may one day receive this hormone. Can you think

shorter than every other kid his age—and he fought with anyone who teased him about it.

By the time he turned eight, he had stopped growing, and by age 10, he stood only 4 feet and one inch tall.

Russell's mother told him it was time he grew up—physically and emotionally. She knew it was possible, thanks to a drug called human growth hormone. Though it occurs naturally inside the body, scientists have isolated the gene and created a synthetic form of the hormone. Approved by the Food and Drug Administration in 1985, it can help children who are abnormally short start growing at a normal pace. It can actually add inches to their height.

Russell wasn't so sure; he didn't want to take the drug. "Why should I have to take it when other kids don't?" he protested. "He felt singled out," his mother says. He resented being different from everyone else.

But his mother insisted. If Russell was ever going to be taller, she knew he couldn't afford to wait much longer.

"My older son stopped growing at 15," she says. "Once your bones stop growing, you stop growing. And Russell had only a few years left for the growth hormone to work."

Three years later, at age 13, he stands five feet. He is eleven inches taller than before he began taking human growth hormone.

And he doesn't fight his disability anymore. In fact, says his mother, he has settled down a lot; he's not nearly so feisty as when he was short. Now that his weight has stabilized and he looks trimmer, he likes the way he looks in the latest clothes. Even his teeth fit better in his mouth; he can smile without feeling self-conscious.

While human growth hormone is expensive (the drug company subsidizes all but $5,000 of the $30,000 it costs per year), it's been worth it.

Russell continues to take the drug—he injects himself six days a week—and he'll keep taking it until puberty.

And while he doesn't discuss it with his friends, he does attend a support group for children with similar problems.

"It's a big help to the kids, and their parents," says his mother, who is president of her local chapter of the Human Growth Foundation. "They like having each other to talk to about what they're going through."
of other possible uses for the human growth hormone?

Doctors hesitate to give the hormone freely. We don’t understand all the side effects of this drug just yet. Given in large doses, human growth hormone can cause arthritis, diabetes, heart failure and high blood pressure.

A “black market” has arisen around human growth hormone. Athletes who don’t want to use steroids may take human growth hormone to build muscles. The hormone cannot be traced with drug tests. Parents who want their normal kids to grow taller also try to get doctors to prescribe the hormone treatment.

These kinds of drug abuse have led pharmaceutical companies to explore ways to prevent potential abuses. One idea under study is a “suicide gene” that would make the hormone self-destruct and become inactive if its levels became too high in the body.

The production of human growth hormone serves as a good example of how biotechnology helps people with medical problems.

**WHAT IS A HORMONE?**

**A little hot sauce goes a long way.**

The same is true for hormones. Only a small amount is needed for a hormone to do its job.

A hormone is a natural chemical made in one part of the body that then travels to another part of the body to cause some action.

All the various hormones that make up the “endocrine system” need only exist in very small amounts to trigger the appropriate response in a target cell. Just like the spice-sensitive taste buds on your tongue are activated by the tiniest bit of hot sauce.

When a hormone is released in the body, it travels until it finds and binds to a protein “receptor” on the outside or on the inside of the target cell. Once the hormone binds to the receptor, a chain reaction occurs.

Three Hormones and Their Actions

**INSULIN:** Triggered by eating food. Released insulin causes liver cells to take in sugar.

**EPINEPHRINE:** The “flight-or-fight” hormone. Released as a response to a life-threatening situation. Epinephrine (also called adrenaline) can help some people perform superhuman acts, like lifting a car off a trapped friend.

**CORTISONE:** Released to help fight inflammation. Cortisone sometimes helps people with arthritis.

Can growth hormone help some older people?
The Onion Lab: DNA Spooling

Introduction

The process of isolating DNA from a cell is the first step for many laboratory procedures in biotechnology. The scientist must be able to separate the DNA from the unwanted substances of the cell gently enough so that the DNA is not broken up or sheared. The procedure you will be doing is a modification of the "Marmur preparation" which is used worldwide in biotechnology laboratories.

Once you have completed the procedure, it is possible to test the material you have isolated with an indicator to determine whether or not it is DNA.

Your teacher has already prepared a "filtrate" for you, made of onion treated with salt, distilled water and dishwashing detergent. We use an onion because it has a low starch content, which allows the DNA to be more clearly seen. The salt shields the negative phosphate ends of DNA which allows these ends to come closer so they can precipitate out of a cold alcohol solution. The detergent causes the cell membrane to break down by emulsifying the lipids and proteins of the cell and disrupting the polar interactions that hold the cell membrane together. The detergent then forms complexes with these lipids and proteins, causing them to precipitate out of solution. You will be altering the filtrate so that you can "spool" DNA out when it precipitates.

DNA Spooling

Materials (obtain from your teacher)

For each lab team:
- 1 test tube containing 6 ml of onion filtrate
- 1 plastic pasteur pipette
- 9 ml of ice cold ethanol
- 3.5 ml of meat tenderizer solution
- 1 glass rod (or use your plastic pipette)
- 1 test tube containing 3 ml 4% NaCl solution

Procedure

1. Fill up your pasteur pipette with the meat tenderizer solution until the bulb is half full (3.5 ml). Add the solution to your test tube with the onion filtrate and swirl to mix. Meat tenderizer contains papain, an enzyme that will clean extra proteins away from DNA.

2. Immediately add 9 ml of ice cold ethanol to the test tube from step 1 by slowly pouring it down the side of the test tube creating a layer on top. DNA is not soluble in ice-cold ethanol. When it is added to the mixture, all the components of the mixture except for DNA stay in solution while the DNA precipitates out.

3. Let the ethanol sit for 2-3 minutes without disturbing it. Bubbles will form and you can watch the DNA precipitate out of the solution.

4. Gently swirl the DNA using a glass rod (or your plastic pipette) until the bubbles disappear. You should be able to lift the DNA out of your test tube. (It will look like whitish mucus.)

5. Carefully put the DNA into the test tube containing NaCl solution.

DNA Testing

Materials (obtain from your teacher)

Each lab team will need:
- 1 test tube containing 3 ml DNA standard solution
- 1 test tube containing 3 ml distilled water
- 9 ml of diphenylamine solution

Procedure

1. Stir the DNA from the onion with your glass rod to resuspend the DNA into the NaCl solution.

2. Add 3 ml of the diphenylamine solution to the DNA suspension.

3. Add 3 ml of the diphenylamine solution to the test tube containing the DNA standard and 3 ml to the test tube containing distilled water.

4. Place all the tubes in boiling water for 10 minutes and record the color changes. Diphenylamine reacts with deoxyribonucleic acid of DNA to produce a blue color.

Questions

1. Explain the effect that detergent has on the cell membrane.

2. What other vegetables might be used for this lab?

3. Name three properties of DNA that are demonstrated by this lab.

4. Write a short paragraph describing the universality of the DNA molecule.

5. Scientists all over the world use adaptations of this classical method of DNA extraction. The DNA isolated in this manner is routinely used in cloning experiences. This method is commonly used with E. coli bacteria and some strains of yeast. What common biological characteristics exist between E. coli, yeast and an onion that allow this technique to be effective with all three?

*From (A Sourcebook of Biotechnology Activities) published by the National Association of Biology Teachers and the North Carolina Biotechnology Center. This experiment was developed by Judi Brown of the Paint Branch High School in Burtonsville, MD in conjunction with biotech workshops conducted by the North Carolina Biotechnology Center. Reprinted with permission.
First comes fever, then depression, then restlessness that turns into uncontrollable excitement. The muscles of the throat convulse, and saliva froths and runs down the chin, causing great thirst. But even the smallest sip of water may produce convulsions and more thirst. In the later stages of the disease, the mere sight of water can bring on convulsions and paralysis thus the archaic name for the disease, hydrophobia, "fear of water." After four or five days of this kind of suffering, death can be a blessing.

From *The Invisible Invaders*  
By Peter Radetsky

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**Stopping Rabies And**

**Biotechnology Under Development**

Pretty horrible, the description of rabies running its course. Rabies can spread easily among pets and wild animals. The disease drives these animals to bite and pass on the disease. A person bitten by a rabid animal can die if not treated.

We now vaccinate our pets to protect them from rabies so only a few cases of rabies
Once the rabies virus enters an animal's body, it reproduces and multiplies in the muscle cells. Next, it spreads throughout the nerves to the brain and salivary glands. Or, it may skip the muscle cells altogether and move directly to the brain and salivary glands.

No matter how the virus develops, after rabies reaches its brain, the animal just wants to bite. The rabies virus can infect any warm-blooded animal such as raccoons, squirrels, dogs, cats, cattle, other wildlife, and even humans.

If rabies can create such a problem, why don't we hear more about it? Why isn't something being done to get rid of the virus?

We don't hear much about rabies in the United States because we vaccinate our pets against the disease. Also, other health problems occur more often and affect more people. As for something being done — scientists developed a rabies vaccine over 100 years ago. Now, researchers are trying to make a vaccine for use with wild animals.

**Vaccines for Rabies Treatment**

Louis Pasteur produced the original rabies vaccine in 1885. Pasteur was a famous French scientist who made many major discoveries and greatly advanced biology and medicine.
In developing the rabies vaccine, Pasteur joined a piece of the rabies virus with another microbe that acted as a carrier. The piece of the rabies virus did not cause the disease itself because it was not complete. Pasteur then injected the incomplete virus into animals. It triggered the production of natural chemicals called antibodies. These antibodies allow the animal or person to fight against infection by the rabies virus.

The body usually responds to a vaccine by making antibodies. The antibodies act like a highly specialized microscopic police force. Without antibodies and the immune system, we would catch every disease that crossed our path. Without antibodies, we would be sick all the time and have a very short life span. This trained antibody force recognizes specific viruses — in this case, the rabies virus. The antibodies arrest the development of the disease.

Pasteur's vaccine has saved many people bitten by rabid animals. People vaccinated do not suffer the horrible death that used to follow infection. But Pasteur's vaccine had a big drawback. The bitten person or animal had to receive 14 to 21 painful shots in the abdomen.

In the 1960s, scientists at the Wistar Institute of Anatomy and Biology in Philadelphia, Pennsylvania, tried to solve this problem. They created a new vaccine that eliminated much of the pain and agony of Pasteur's method. The Wistar vaccine requires only four to six injections in the arm.

The vaccines by Pasteur and the Wistar scientists work, even after infection, because rabies is a "slow virus." It can take a long time for the disease to develop. The amount of time it takes for an infected person to show rabies symptoms depends on a lot of factors, including:

- The amount of virus injected into the wound.
- The strength of the virus.
- How close the wound is to the central nervous system.

If the infected person or animal receives the vaccine very soon after being bitten, the body can make lots of antibodies quickly. The faster the antibodies appear, the faster the body can overpower the rabies virus and prevent the disease from fully developing.

Before 1960, most rabies cases in the United States occurred in pets — usually in dogs and cats. Vaccination programs for domestic animals reduced the cases of rabies by 85 percent. But animals in the wild do not get vaccinated, and cases caused by wild animal bites have tripled during the past 30 years.

Pasteur's and Wistar's vaccines do stop the rabies infection, but they are used only after exposure to the virus. These vaccines cost too much to vaccinate every person or every animal for rabies before they are exposed.

**Vaccines for Rabies Prevention**

We can reduce the number of people infected with rabies by controlling the virus in nature. Because of their past rabies research, scientists at the Wistar Institute began working on a vaccine for wild animals. They studied several different possibilities for creating such a vaccine. Finally, they decided to use the novel methods of biotechnology.

After much research, they developed a recombinant vaccine. A recombinant vaccine is made by combining parts of two different viruses using modern molecular biology procedures.

Working in laboratories, the Wistar scientists took a small piece of genetic material, the DNA, from the rabies virus. This genetic material was then placed into a
Vaccinia virus, which served as the carrier part of the vaccine. By itself, the piece of rabies virus cannot cause the disease. But when it joins up with the Vaccinia virus and is eaten by an animal, the recombinant vaccine causes the animal to make antibodies to the rabies virus. The figure on the previous page shows the vaccination and virus introduction process. The next problem was how to vaccinate the animals. Most wild animals don't see a veterinarian very often. The Wistar Institute scientists had to think of another way to get the vaccine into the wild animals.

They came up with a tasty tidbit of bait that would hold the vaccine. The bait contains fish meal, fish oil, and binders that hold everything together. The mixture may sound pretty disgusting to humans. But the animals that cause most rabies infections find it very attractive.

When an animal eats the bait, it becomes vaccinated. As more and more animals eat the vaccine-filled tidbits, the spread of the virus slows.

**To be or not to be vaccinated?**

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The recombinant vaccine may reduce — and possibly wipe out — rabies infection. But the vaccine cannot be used just yet. Lots of tests of the vaccine must be done to check its safety and effectiveness. Because the vaccine is used outdoors, scientists have to show it's safe for the environment. Proving these things takes time. The researchers have to carefully design different kinds of experiments to test that the vaccine really works.

The vaccine was first tried out on Parramore Island, an undeveloped strip of land off Virginia's eastern shore. The researchers placed the vaccine-filled bait at different spots around the island. The bait appealed especially to the raccoons. Results from this study show that the vaccine works and is safe. The experiments succeeded!

Recently, the Wistar Institute scientists finished field trials of the recombinant rabies vaccine in Pennsylvania. They plan more field tests in other parts of the United States soon.

Field studies have also been carried out with the help of fellow researchers in Canada, Europe, and China. Because of the very successful results of the field tests, the French Ministry of Agriculture and Forestry has given their consent, and the vaccine can now be used in France to control the spread of rabies among wild animals.

**The Research Goes On**

Scientists have not stopped their work. They keep on looking for new ways to improve the recombinant rabies vaccine. They intend to make it easier to use and less costly. Better vaccines could speed up the elimination of rabies, especially in countries where it's a major health problem.

The recombinant rabies vaccine faces one important question: "Are people willing to give wild animals a vaccine made by new methods that combine genetic material from two viruses?"

What do you think about vaccinating wild animals against rabies with a recombinant vaccine? Do you have any questions about the use of such a vaccine?
Biotechnology On The Horizon

Cleaning Up Chemical Waste

Oil and gas are extremely useful chemicals. Gasoline makes our cars run, and oil is the basic building block of countless products, from lipstick to compact discs.

When properly stored and disposed of, oil and gas pose no threat to our natural environment. But occasionally because of an accident or as the result of negligence, they pollute our land and water.

News headlines often report major chemical or oil spills. A recent incident is the giant oil spill from the tanker Exxon Valdez off the coast of Alaska.

But oil and chemicals reach the environment in other, quieter ways. They might leak slowly from storage tanks at industrial sites. Or leak from waste disposal sites or landfills. These leaks can go unnoticed for a long time, and can seriously contaminate the soil and our drinking water.

Cleaning Up Spills the Old-Fashioned Way

The old-fashioned way of cleaning up contaminated soil is pretty simple. You dig it up or somehow mop it up. Then you put the contaminated soil or chemicals someplace else. This creates an environmental shell game. The waste isn't eliminated, it's just moved to a "safer" place.

Treating polluted water, especially underground, is even more difficult. Because it's a difficult and expensive problem to solve, once the source of contamination is stopped, we often just wait for nature to take its course. Fresh rain and mountain runoff eventually dilute the chemical until it's no longer dangerous. But "eventually" could mean decades or even centuries.
Today, exciting discoveries are leading to new ways to attack chemical contamination, and biotechnology has become part of the solution for cleaning up the environment.

**Bioremediation and “Biotech Bugs”**

A new strategy for cleaning up chemical spills uses microorganisms that can break down oil, gasoline, or other compounds into harmless chemicals. Microorganisms, or microbes, are life forms so small they can only be seen with a microscope. In one tablespoon of soil, you could find 2,500,000,000 — that’s 2.5 billion — of them. But what can such small creatures do against a massive oil spill?

Microbes have an appetite for chemicals. They live everywhere in the environment—the air, the soil, the water, and just like us, they need food. Their kind of food, in the microscopic world, looks more like a chemical diet than a burger and fries.

Certain microbes have a hardy appetite for oil, gasoline, or other toxic chemicals. When the chemical is digested by the microbes, its structure undergoes a change. And the right microbe can change a toxic chemical into something harmless, for example, water and carbon dioxide. Enough microbes digesting can make a big dent in a spill. **This process is called “bioremediation,” which means using a living organism to return the environment to its natural state.**

Finding the right microbes for a particular chemical is the tough part. Sometimes, even when you find a microbe that can do the job, it isn’t very good at it.

Enter biotechnology! Biotech methods can add new information to the microbe’s genetic makeup so that it is more efficient at breaking down chemicals. New genetic information can also change the microbe so that it craves a different chemical.

**Cleaning Up Large Spills with Small Microbes**

After finding the right natural, or genetically-engineered, microbe, scientists must produce many, many of them to tackle a large oil spill. One way to do this is to grow lots of microbes, then take them to the contaminated area. Another way is to grow them at the contaminated site in a bioreactor. A bioreactor is a whole rig of equipment in which microbes and contamination come together. Your local sewage treatment plant is a bioreactor that processes human waste.

Of course, if the right microbes already live at the contaminated site, scientists can figure out what will help the population to grow large enough to tackle the job (maybe more oxygen or a special fertilizer), and add it. Through bioremediation, you don’t just move a problem elsewhere — you actually solve it. And perhaps at a much lower cost — toxic clean-up can be extremely expensive!

**Safety Nets**

Some people are concerned that these super bugs won’t know when to quit. Fortunately, microorganisms need more than one kind of food to live. They need many nutrients not found in a tank of oil or gasoline. Others worry that these super bugs could crowd out the natural microbes in the environment. But super bugs act as specialists at one particular task. They can’t compete with, or compete with, their natural cousins - the well-rounded organisms nature created.

Scientists also work to add safety features to the super bugs, like a “suicide gene” to keep the genetically-engineered microbes under control. The suicide genes would tell the microbes to turn off after a certain life span. The bugs would live fast, then die.

No genetically-engineered organisms have been approved yet by the Environmental Protection Agency (EPA) for release into the environment. The EPA continues to work on guidelines to regulate the use of genetically-engineered organisms in the United States.

Bioremediation has gotten off to a good start. But don’t think we’ll have the environment cleaned up in a couple of years.
Oil contamination lies on the sand's surface and begins to invade the sub-surface. Some naturally occurring oil-eating microbes are present.

We've created such complicated chemicals that a purely natural organism might not work on some of them. And biotechnology may help by making special, genetically-engineered microbes for complex pollution problems.

**Crude Oil**

Recently, one of the biggest microbiology experiments ever took place. Microbiologists believed that they had a solution to the Exxon Valdez oil spill. The oil tanker Valdez had leaked 10.1 million gallons of crude oil into the ocean off Alaska! The microbiologists travelled to Alaska to test a new method for cleaning up oil spills.

Cleaning up an oil spill is challenging. The methods we most often use have their problems. Because of this, biologists have been looking for ways that biotechnology and microorganisms might provide part of the answer.

Scientists have known for over 90 years that some microbes can use oil as a carbon source. Biologists also knew that oil-eating bacteria are present in water samples taken from around the country. They were almost certain to find bacteria in the Alaskan water that could naturally degrade the oil from the Exxon Valdez.

Fertilizing the land near the spill would give the resident bacteria prime growing conditions. Biologists prepared a special nitrogen and phosphorous fertilizer. Time was of the essence so without even identifying the bacteria to be sure they liked oil as a carbon source, they took a gamble. They sprayed the shore with the fertilizer.

The effects were evident within 15 days and lasted five months. In some sprayed areas, concentrations of bacteria were 100 times higher than normal. Scientists calculated that the fertilizer sped up the natural breakdown of oil by two to three times the normal rate.

Research into how micro-organisms can clean up oil spills continues. Perhaps someday, this research will lead to a biotech bug that can help decrease the damage caused by a spill.

The faster we clean up an oil spill, the less damage to marine and shore life, drinking water, and to your world and our world.

**Gasoline Tanks**

You know how many gasoline stations you see in your neighborhood or town. Imagine the thousands and thousands of gas stations all over the United States. Now imagine the underground tanks beneath those stations that store the gasoline before it's pumped.

Sometimes these storage tanks have been buried for many years and gradually develop leaks. The leaks can go undetected for a long time and can be very serious, especially if gasoline seeps into the underground water supply.

Leaking tanks are dug up and replaced, but the contamination stays around. Bioremediation can also help clean up this pollution. By adding oxygen and other "food," naturally-occurring microbes can break down the gasoline contamination.

Tanks installed today in new stations, or replaced in older ones, are built of modern plastic materials that better resist natural damage. In the meantime, bioremediation offers a cure for ground and water pollution problems.
Dear students and teachers,

We think it is important for you to understand the part science and scientists play in "our world". That is why we are proud to bring "Our World" to you. This publication is meant to inform you, to educate you, and hopefully to inspire you.

We sincerely hope that a better understanding of science and in particular, biotechnology, will help you to understand the developments in "Our World" taking place. To see the promise that the future holds. To feel the excitement of change, and to feel comfortable understanding that change.

It is difficult for your schools to provide you up-to-the-minute materials for the study of a fast-breaking technology like biotechnology. The sponsors listed below have committed effort and money to see that current materials like this issue of YOUR WORLD/OUR WORLD are available. We thank them and we hope that you appreciate their efforts. Good reading and welcome to Our World!!

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