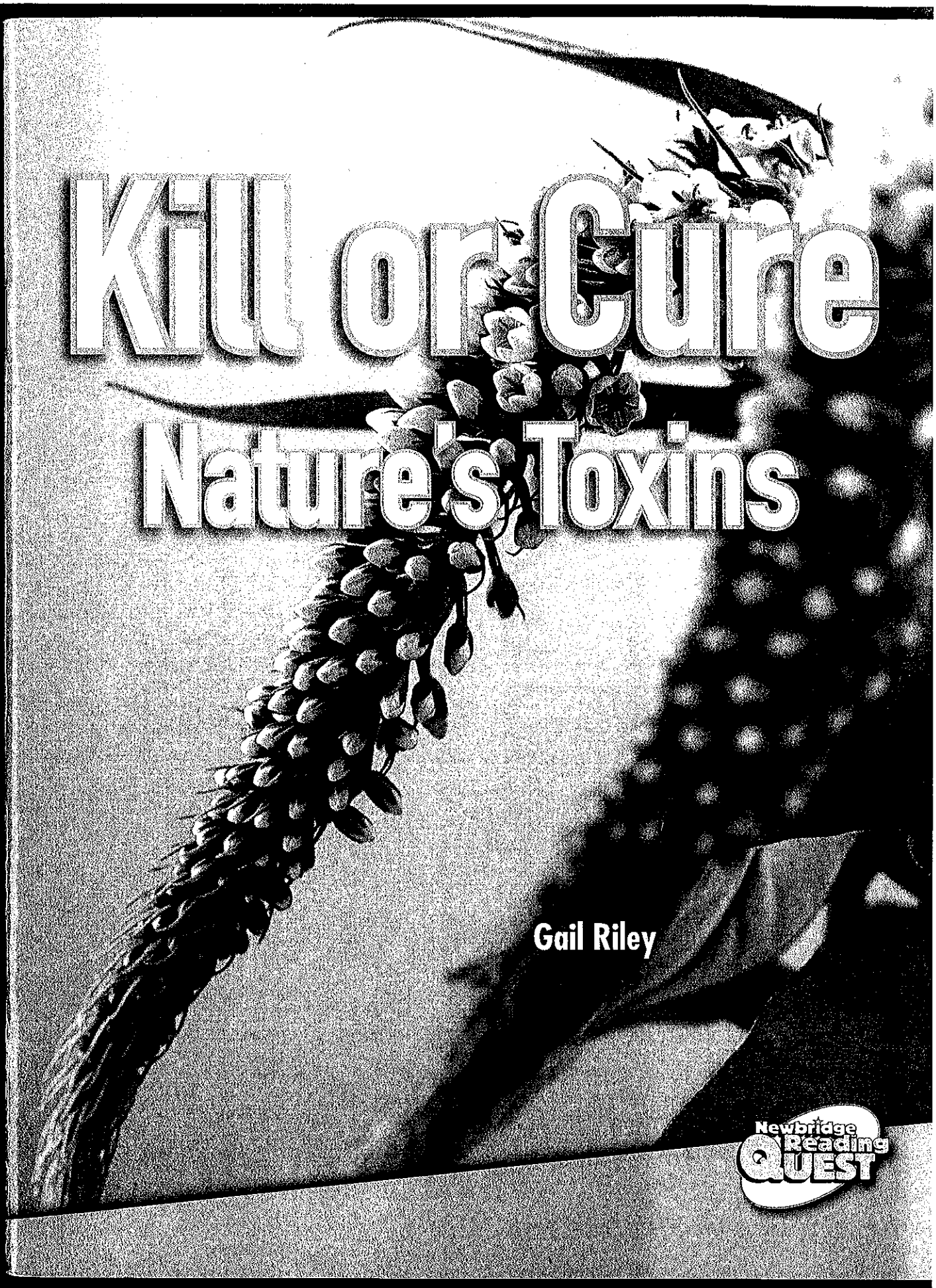


Kill or Cure

Nature's Toxins

Gail Riley

Newbridge Reading QUEST

Before You Read

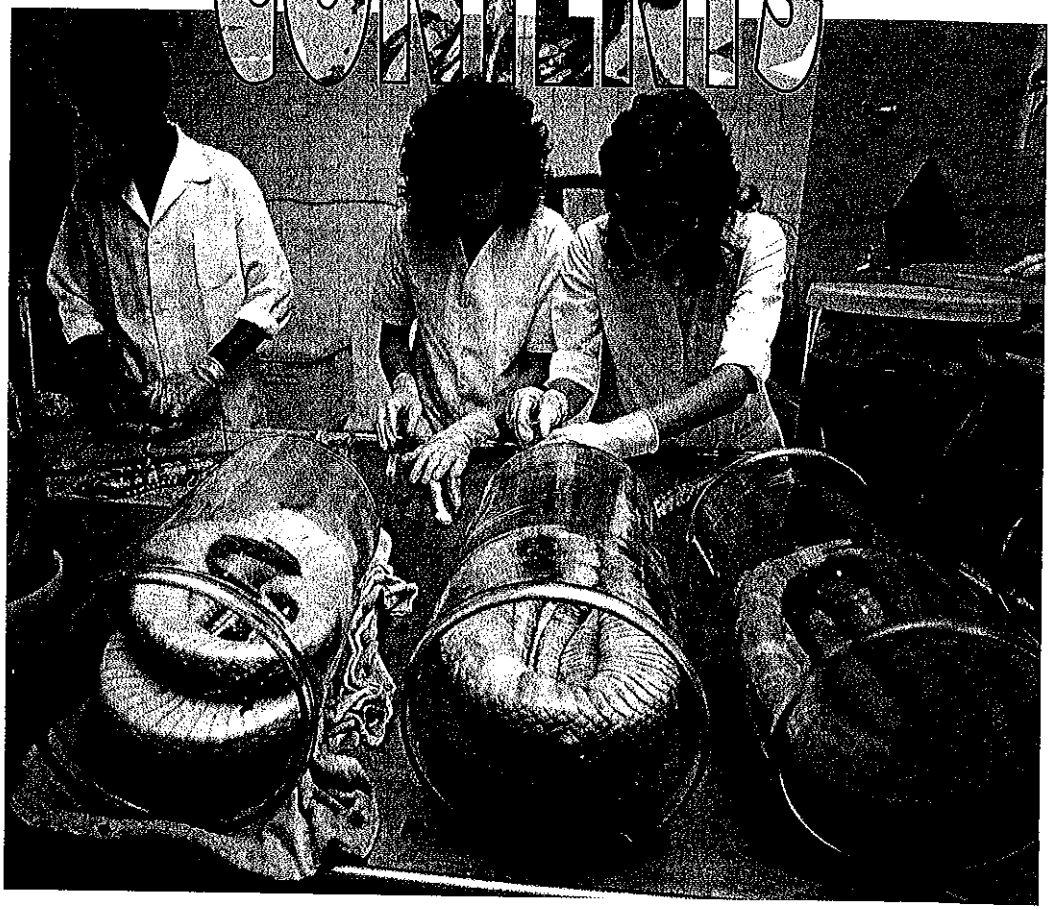
Walking along a country stream, you bend down to pick up a stick. Too late, you realize it's not a stick—it's a poisonous snake! Before you can drop it, the snake bites you. If you don't get treatment quickly, you'll die. Oddly, the same poison that can kill may be able to treat people who have injuries, cancer, or other diseases. As you get ready to read this book, think about the following and make notes.

- What are some poisonous animals or plants you have seen or read about? How do their poisons harm their victims?
- Can you think of anything else that can be harmful in one way, but helpful in another?

Preview the book by looking at the table of contents, headings, photos, and special features.

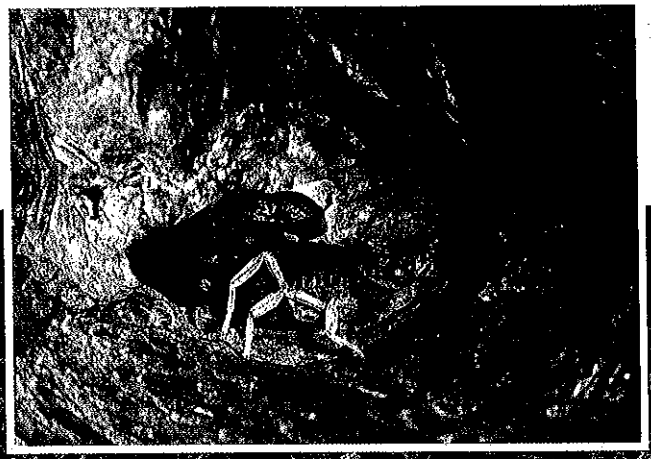
- What do you see in this book that you already know something about?
- List three facts or ideas you think you'll discover in this book.
- Diagrams help you understand how something works. Close-up images within a diagram allow you to see some aspect of the diagram in detail. On page 13, what concept does the close-up of the fang in the diagram help you to understand?
- Write down two questions you have about how poisons can cure.

CONTENTS



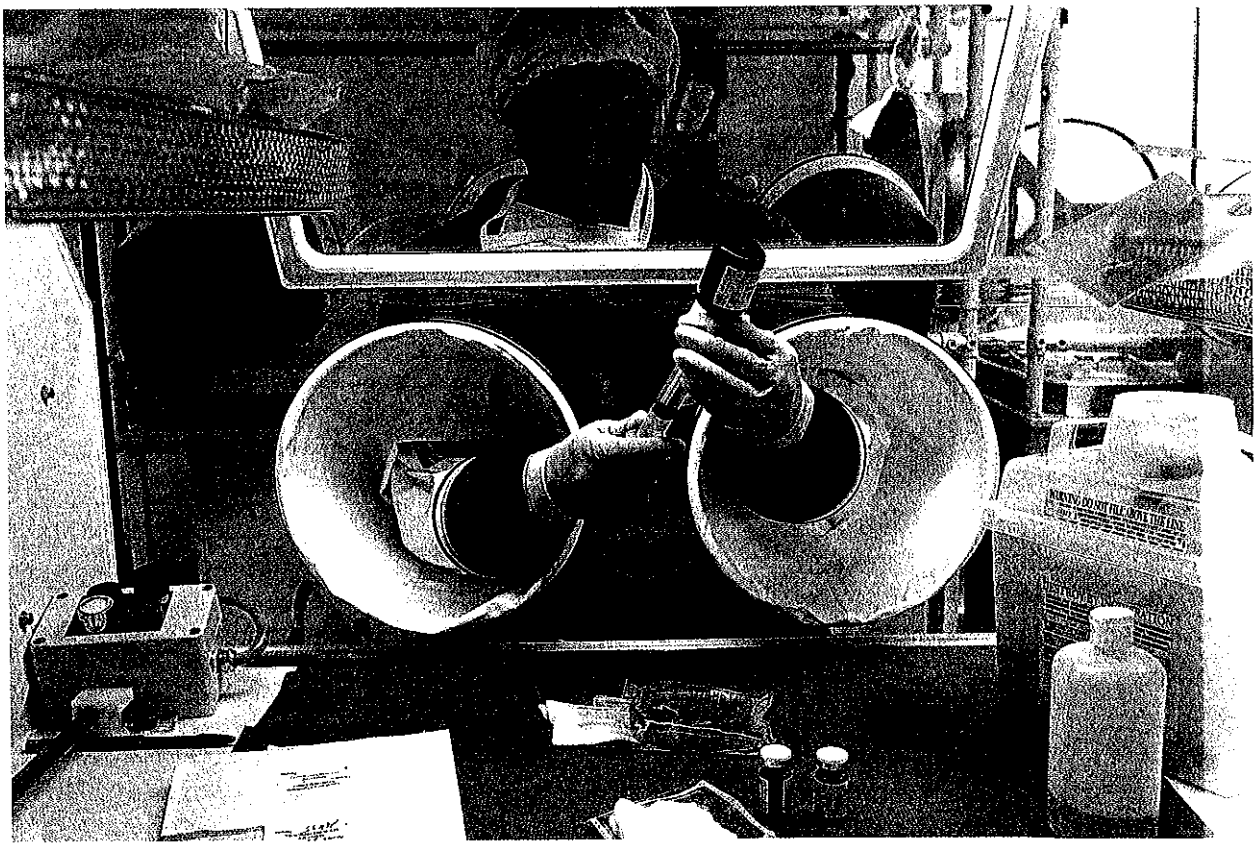
POISON!

Night falls in an Israeli desert. A cockroach skitters across the sand. The vibrations trigger receptors in the hairs of a predator. Slowly the scorpion approaches. It senses its prey coming closer. Suddenly, the scorpion grabs the cockroach in its pincers. It injects searing venom into its victim through its stinger. The venom causes paralysis. The cockroach cannot move. It can do nothing to fend off the scorpion's attack.



The Israeli yellow scorpion lives in the deserts of Israel. Its venom is so deadly that it is nicknamed the Death Stalker.

It's hard to believe, but this deadly venom can be used to heal rather than harm. Scientists are experimenting with the Israeli scorpion's venom. Some of them believe it has the power to shrink brain tumors. For hundreds of years, scientists have been experimenting with poisons **extracted** from animals and plants. They have found that the same **toxins** that can injure or kill can also be used to treat health problems. The Israeli scorpion's venom is only one of nature's poisons that can cure as well as kill.

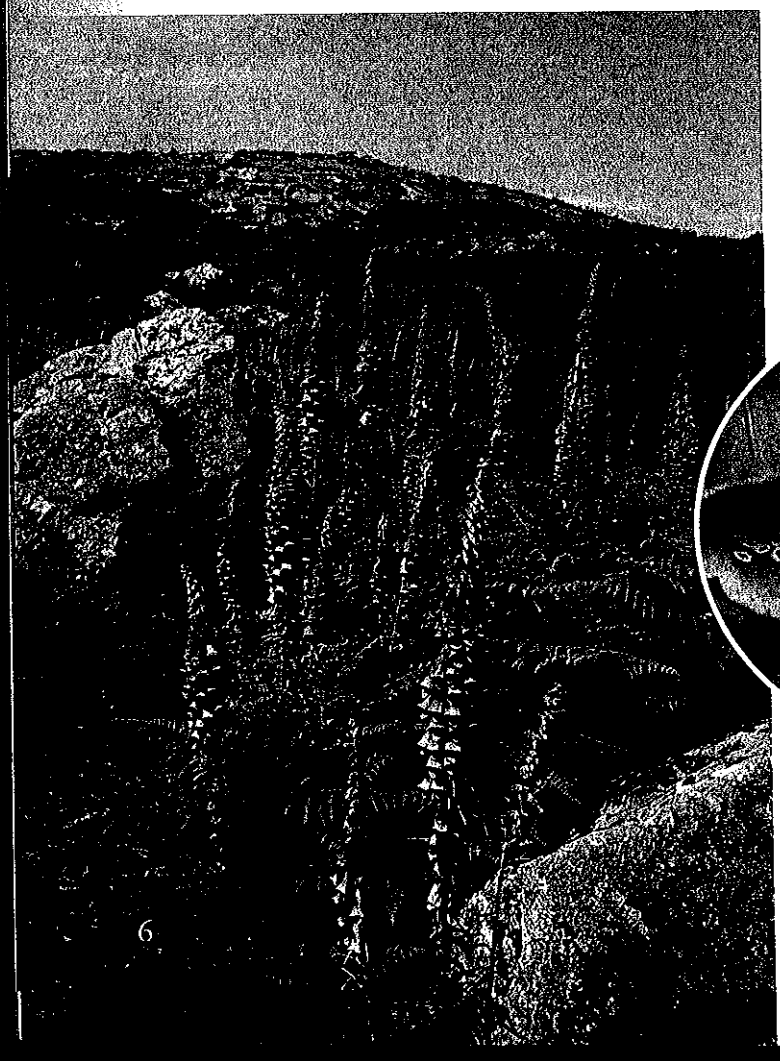


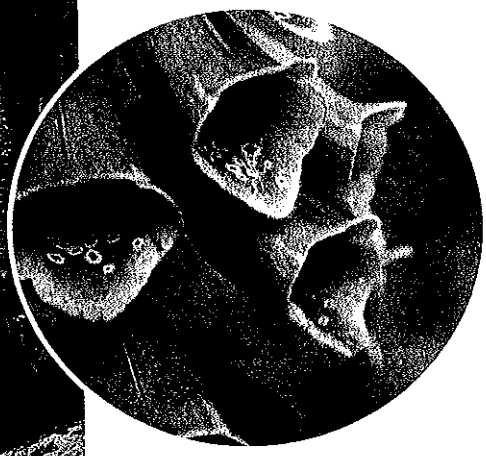
A scientist who studies toxins is called a **toxinologist.** Laboratory safety is an important issue for toxinologists. Sometimes, just breathing in or touching a toxin can be dangerous.

DEADLY LEAVES

The woman sits in a chair, breathing hard. She looks very sick. Her face and arms look gray, and her lips are a fiery red. Her stomach, legs, ankles, and feet are extremely swollen. She is too weak to move, so she just sits in a chair, waiting to die.

If you were living almost three hundred years ago, this dangerous illness might have been familiar to you. In the early 1700s, it was called "dropsy." No one knew much back then about what caused the swelling. People called it "dropsy" because they thought fluid "dropped" from upper parts of the body down to the ankles and feet. Dropsy usually ended in death.





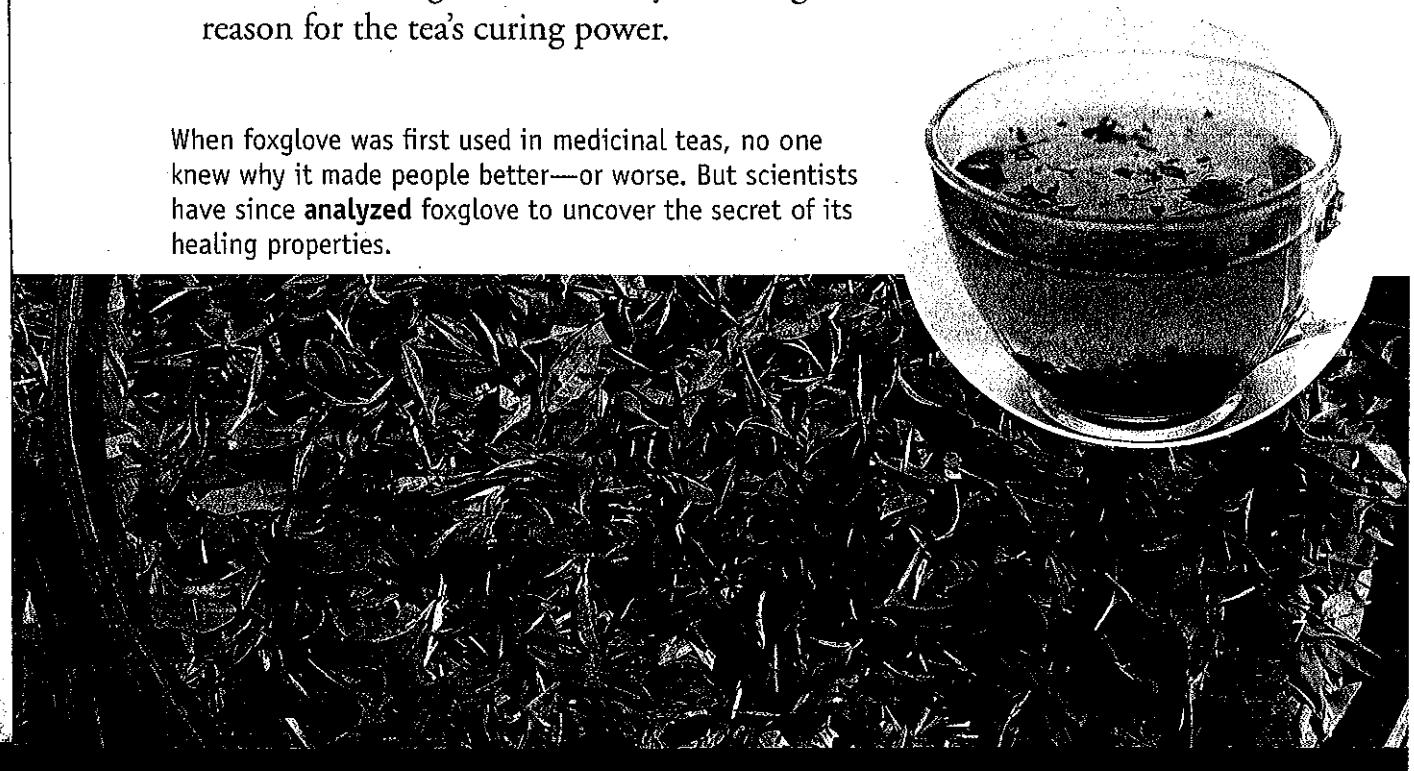
The whole foxglove plant is poisonous. For this reason, it has also been called witches' gloves, dead man's bells, and bloody fingers.

A Cup of Tea

In the late 1700s, a British doctor named William Withering made an important discovery that would help people with dropsy. Many patients came to him with dropsy, but he couldn't help them. One day, to his surprise, one of his patients recovered. But it wasn't because of Dr. Withering's treatment. The patient had visited a woman in the countryside. The woman was known for making medicines out of wild plants she found and picked herself. She had given Dr. Withering's patient a special tea she had made from the leaves of some of these plants.

Dr. Withering searched for the woman. When he found her, she didn't want to give away the secret recipe for her healing brew. But she finally named the 20 different plants she had used. One of those plants was foxglove.

Dr. Withering knew that foxglove was poisonous. People who used too much of it or ate it by mistake suffered dizziness, vomiting, irregular heartbeat, and even death. But Dr. Withering also knew that the plant was often used in medicinal teas. And he knew of studies other doctors had done on foxglove. Going on what he already knew, he made a **deduction.** He guessed correctly that foxglove was the reason for the tea's curing power.

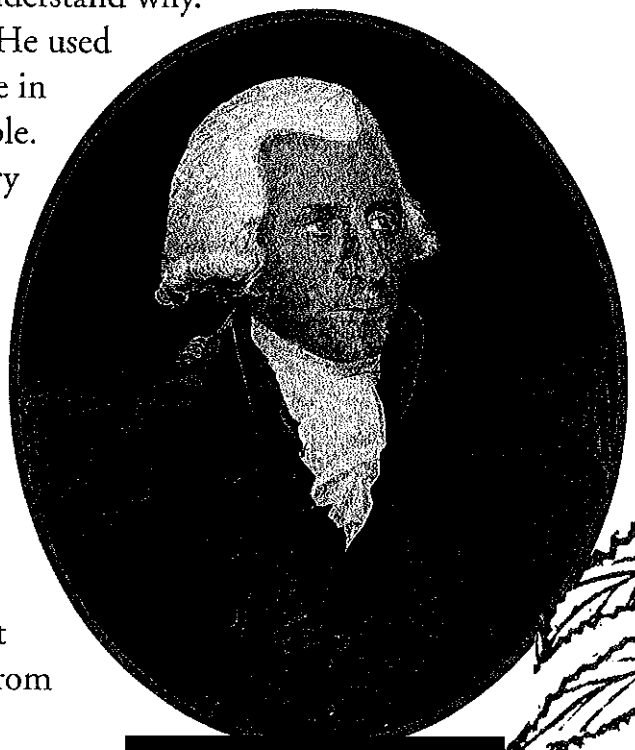


When foxglove was first used in medicinal teas, no one knew why it made people better—or worse. But scientists have since **analyzed** foxglove to uncover the secret of its healing properties.

A Matter of the Heart

Dr. Withering started to prescribe tea made from foxglove leaves for his dropsy patients. Almost everyone who drank the tea improved. Dr. Withering knew that foxglove worked, but he wanted to understand why. So he began experimenting. He used different amounts of foxglove in teas he gave to different people. He recorded notes in his diary about how foxglove affected each person. Dr. Withering knew he had to be careful. He had seen a patient who almost died from drinking too much foxglove tea.

After about ten years, Dr. Withering's research led him to a conclusion. Foxglove made the heart beat faster. That's why tea made from foxglove cured dropsy.

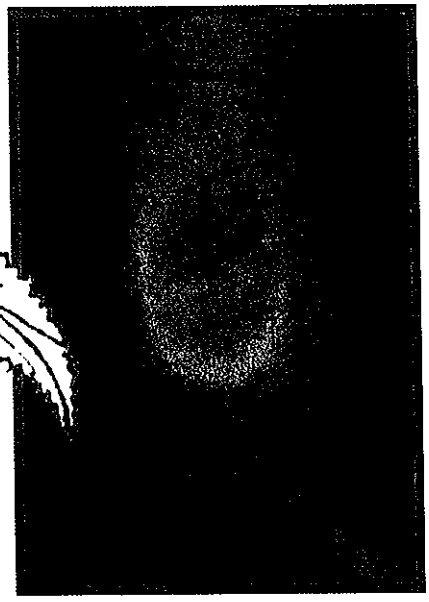


Dr. William Withering

In the late 1500s, a British scientist named John Gerard wrote a book called *The History of Plants*. One of the plants he wrote about was foxglove. He drew a picture of the plant for the book. The scientific name for foxglove is *Digitalis purpurea*.

The cause of dropsy turned out to be a condition people still get today. Now, it is called congestive heart failure. It occurs when the heart cannot pump hard enough to make blood circulate properly through the blood vessels. This means that less blood goes to the body's organs, including the kidneys. The kidneys normally work to get rid of excess body fluid. But if they don't get enough blood, they receive a false message that the body doesn't have enough fluid. They stop doing their work. As a result, the body holds in too much fluid. Excess fluid in the blood vessels leaks into body tissues. Sometimes the feet, legs, and ankles begin to swell. This condition is called **edema.** If fluid leaks into the lungs as well, the patient has trouble breathing.

Withering published a book about foxglove. After his death, others continued to study the plant. And they kept prescribing it for people with dropsy.



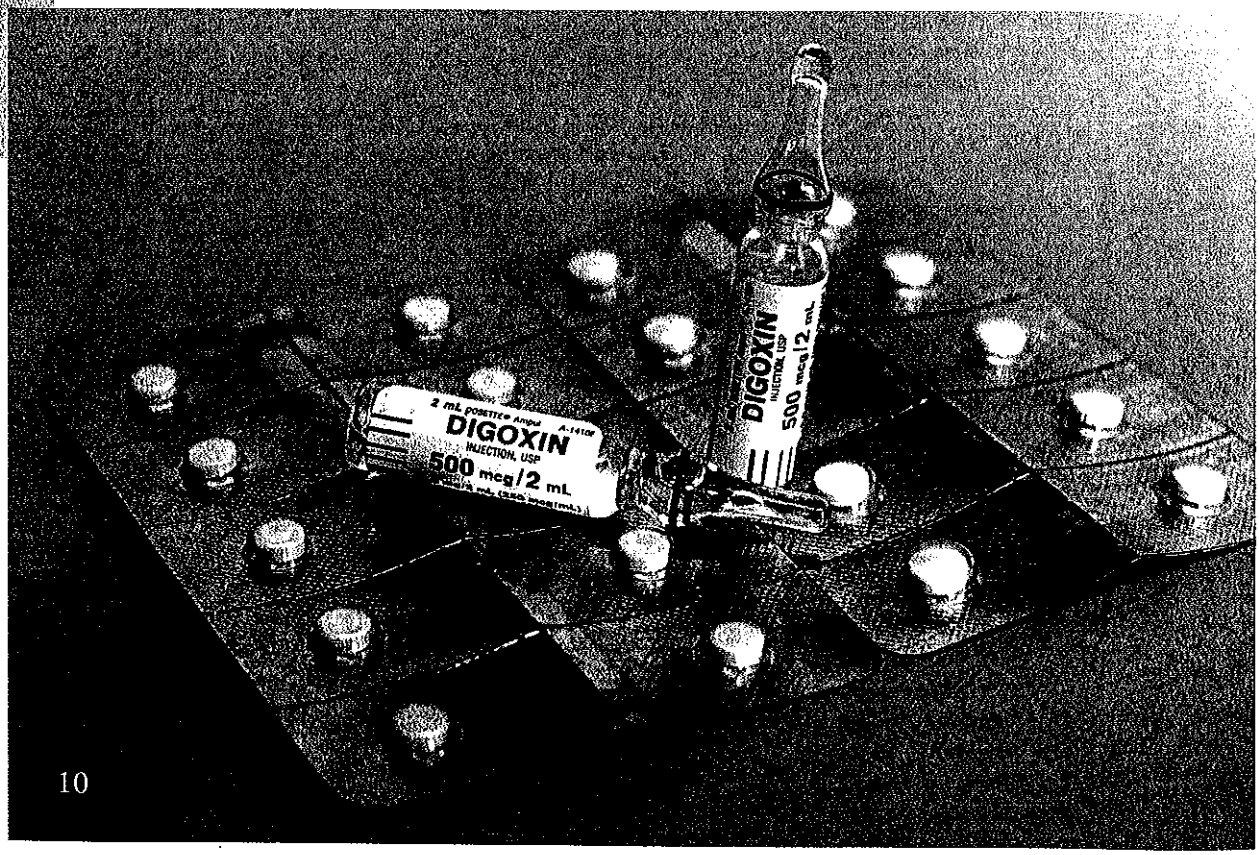
People with edema often have swollen feet that look like this. The word *edema* comes from a Greek word that means "swelling."

Foxglove Moves into Modern Medicine

As years passed, more doctors found out about Dr. Withering's research. They began to understand that dropsy was caused by heart problems. Eventually, scientists figured out which **chemicals** in foxglove leaves were the **active** chemicals that affected the heart. Then they were able to use these chemicals to create a medicine to treat congestive heart failure. That medicine is widely used today. It is called digitalis.

Digitalis stops congestive heart failure by strengthening the heart muscle so it can beat faster. The heart can then send more blood to the kidneys. The kidneys get the message that there is excess fluid in the body. They start working again to get rid of some of the fluid. The swelling goes down, and the patient can breathe more easily. That was what was going on when Dr. Withering gave his patients a special brew of tea.

Foxglove is used to make several different heart medicines. Another is called digoxin.



A Poison and a Remedy

It might be surprising that a woman living hundreds of years ago knew how to make a tea that cured dropsy, but it wasn't unusual. For nearly 6,000 years, people in every part of the world have practiced **folk medicine.** Some of the folk cures were nothing more than superstition. But many of them really worked.

Another folk remedy that worked came from a poisonous plant called deadly nightshade. Eating the shiny black berries from this plant can kill a person. But long ago, deadly nightshade was used with other plants in a mixture that doctors rubbed onto a patient's skin before surgery. The mixture made the patient feel less pain. Also, people drank tea made from the leaves of deadly nightshade to relieve stomach pain and breathing difficulties. Medicines made from deadly nightshade are still used for similar problems.

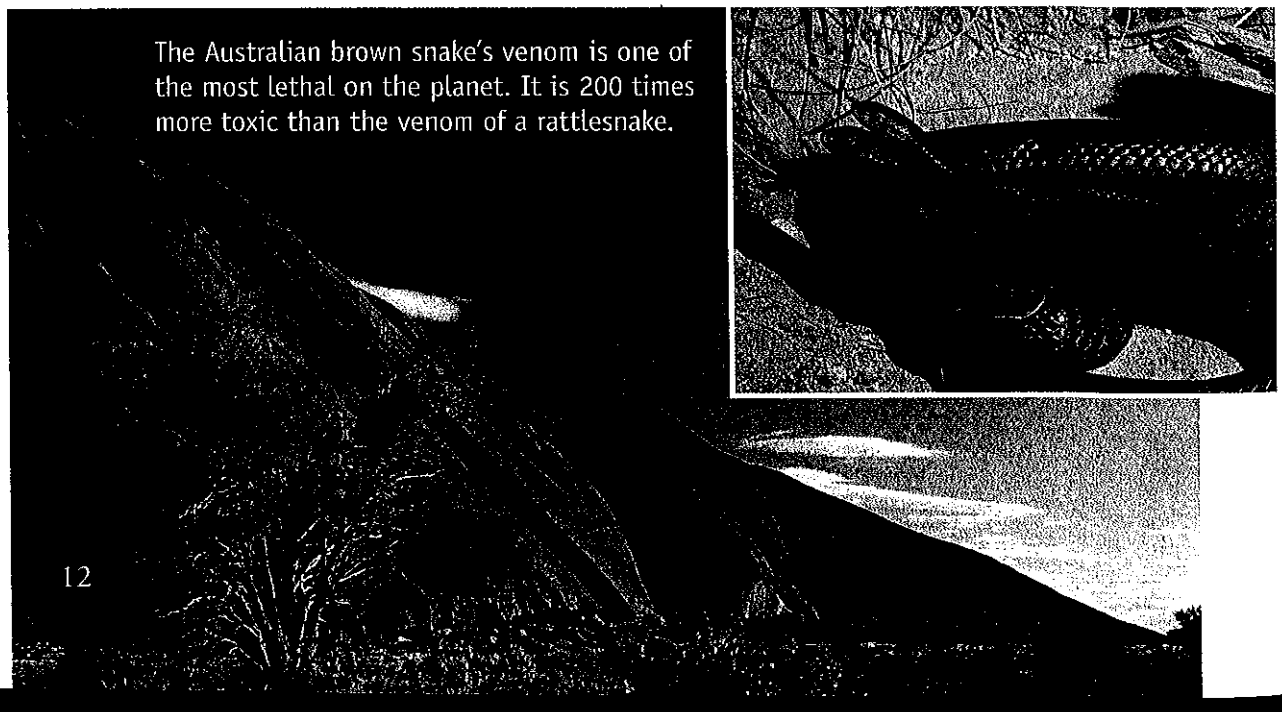
Deadly nightshade contains a chemical called atropine. It's in the drops doctors put in your eyes to dilate your pupils before an eye examination.

SLITHER...STRIKE...SAVE?

On October 15, 2004, George Cox was playing with his little brother near their house in Australia when they saw something stuck in some wire nearby. When they got closer, they saw it was a snake. George touched the snake near its tail, but it didn't move. He touched it again, near its head. But this time, the snake attacked. It sank its fangs into George's hand. Twice.

The snake that bit George was an Australian brown snake, one of the most dangerous snakes in the world. This snake lives in most parts of Australia. Even though it has small fangs, the venom that flows through those fangs can be deadly.

The Australian brown snake usually saves its poison for the prey it hunts, such as rats, mice, birds, and lizards. But just like other snakes, the Australian brown snake also bites as a way to protect itself. That's why when George touched the snake, it sank its fangs into his hand.

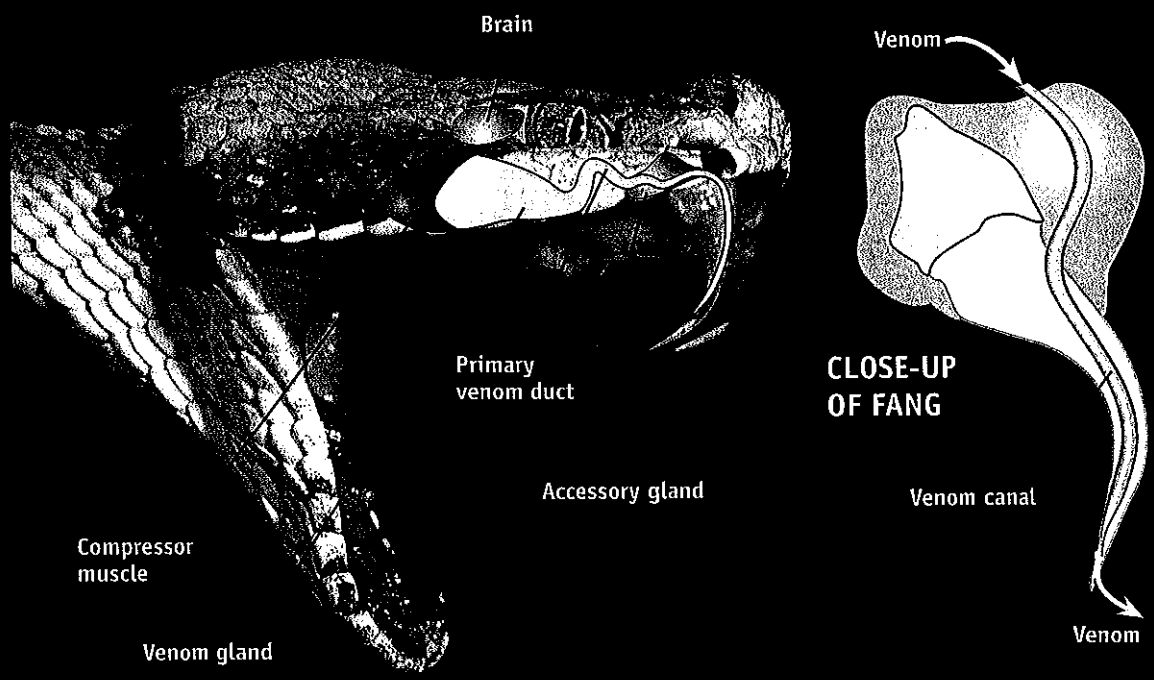


The Australian brown snake's venom is one of the most lethal on the planet. It is 200 times more toxic than the venom of a rattlesnake.

George seemed fine at first. But soon, purple spots started to appear on his skin. Then he started shaking and having a **seizure.** A helicopter rushed him to the hospital. For a frightening 12 hours, no one knew if George would survive.

Doctors gave George a medicine called an **antivenom.** The antivenom counteracted the venom from the snake and saved his life. The Australian brown snake venom almost killed George Cox, but it is also being used to save lives.

Snake Fangs and Venom

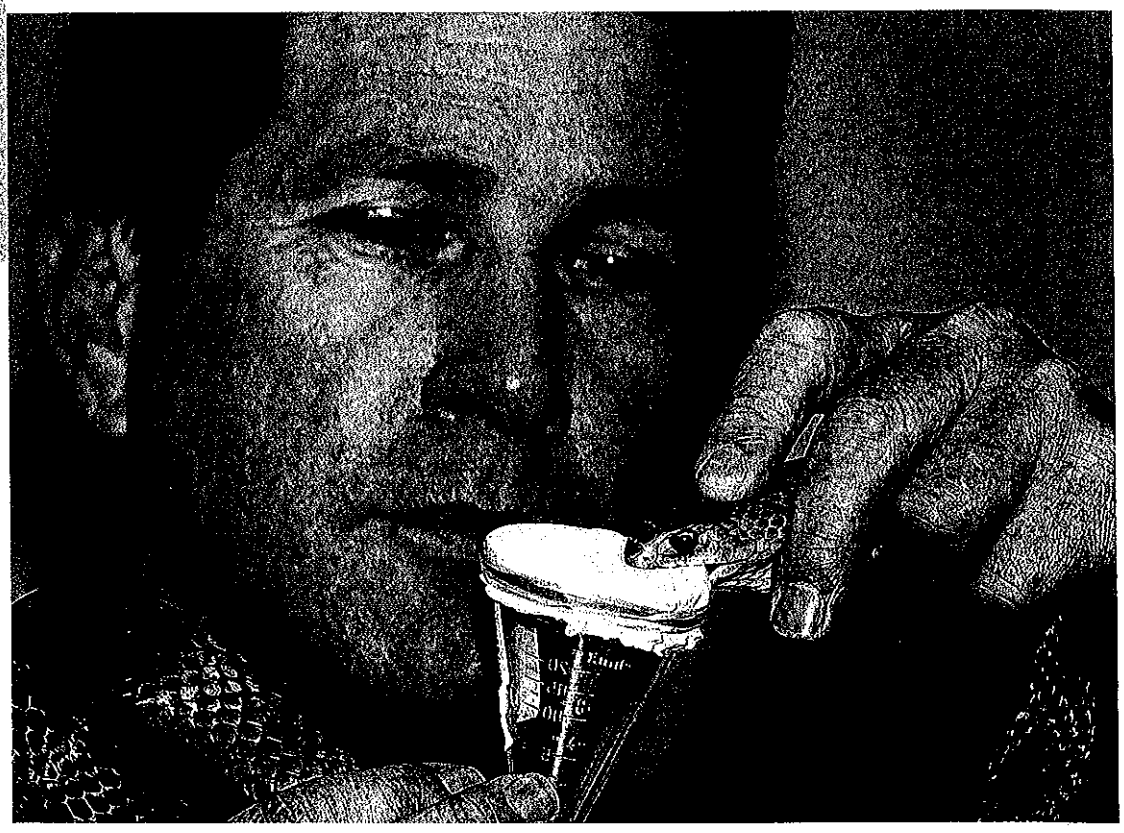


Another Snake Attacks

Neil Charles was cleaning out the cage of an Australian brown snake when it struck. At the hospital, just as they did with George Cox, doctors gave Charles an antivenom that saved his life. They also took a sample of his blood. Doctors usually do this with snakebite patients. They want to see how the venom affects people's blood.

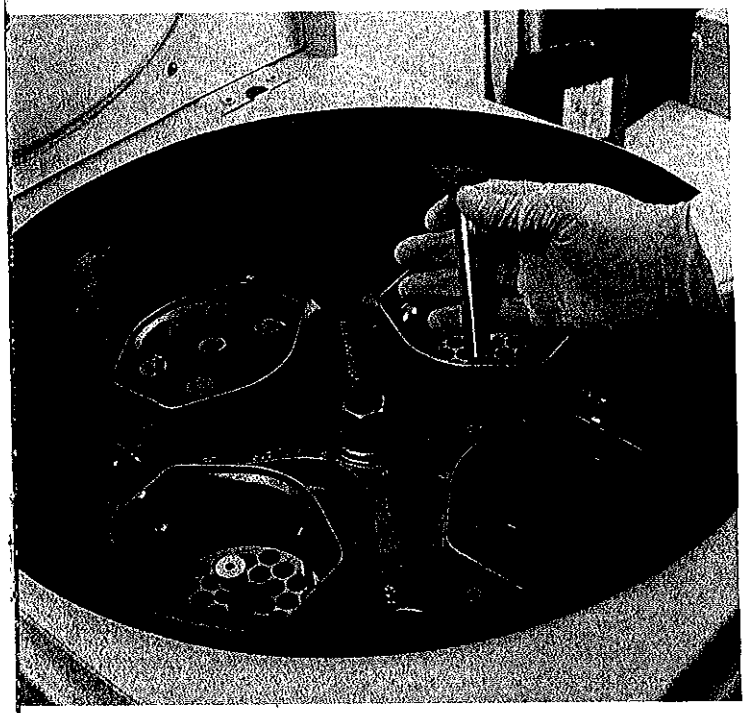
Dr. Paul Masci was one of the doctors at the hospital. He saw that something was happening to Charles's blood before the antivenom took effect. His blood was **clotting** throughout his whole body. Sometimes clotting is good. When a person has a cut, the blood cells clump together around the wound to stop the bleeding. But normally, a

Neil Charles is a professional snake handler. He collects snake venom to give to scientists for research.

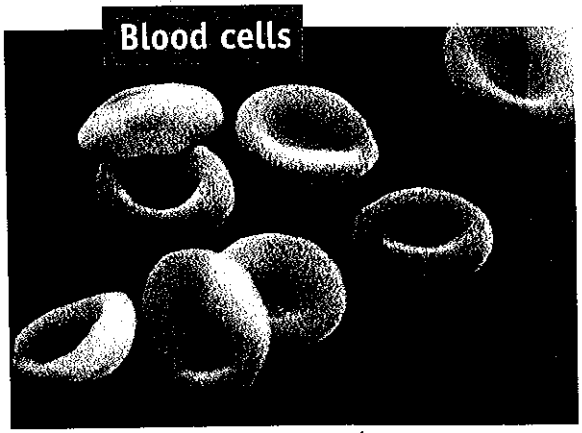


substance called **plasmin** races toward the clot and dissolves it, making it smaller. Then the clot doesn't block the blood vessel, and the person's blood can flow through. But this didn't seem to be happening in Neil Charles's body. Instead, his blood just kept clotting and clotting. If this had continued, his blood would not have been able to circulate through his body. He would have died.

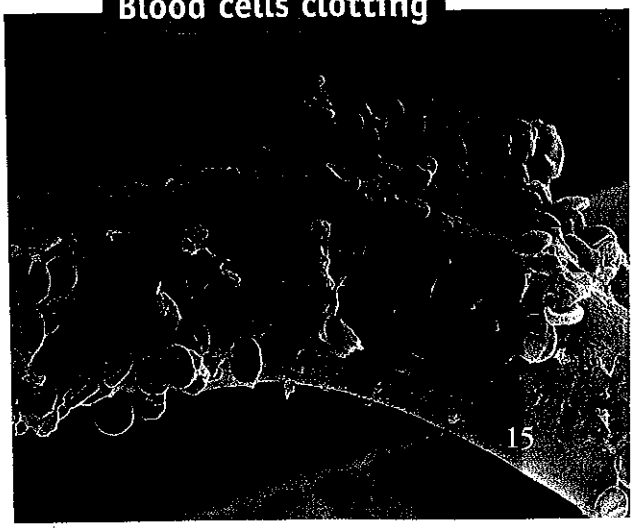
Dr. Masci is a **toxinologist** who studies different kinds of snake poisons. He had already been studying brown snake venom for years. Dr. Masci knew that something in the snake's venom must have been causing Neil Charles's blood to clot. Now he was determined to find out exactly what it was. His research led to a discovery that may one day save thousands of lives.



Doctors and scientists who studied Neil Charles's blood used a machine like this called a **centrifuge.** A centrifuge spins the blood around at high speeds in order to separate the blood into different parts.



Blood cells

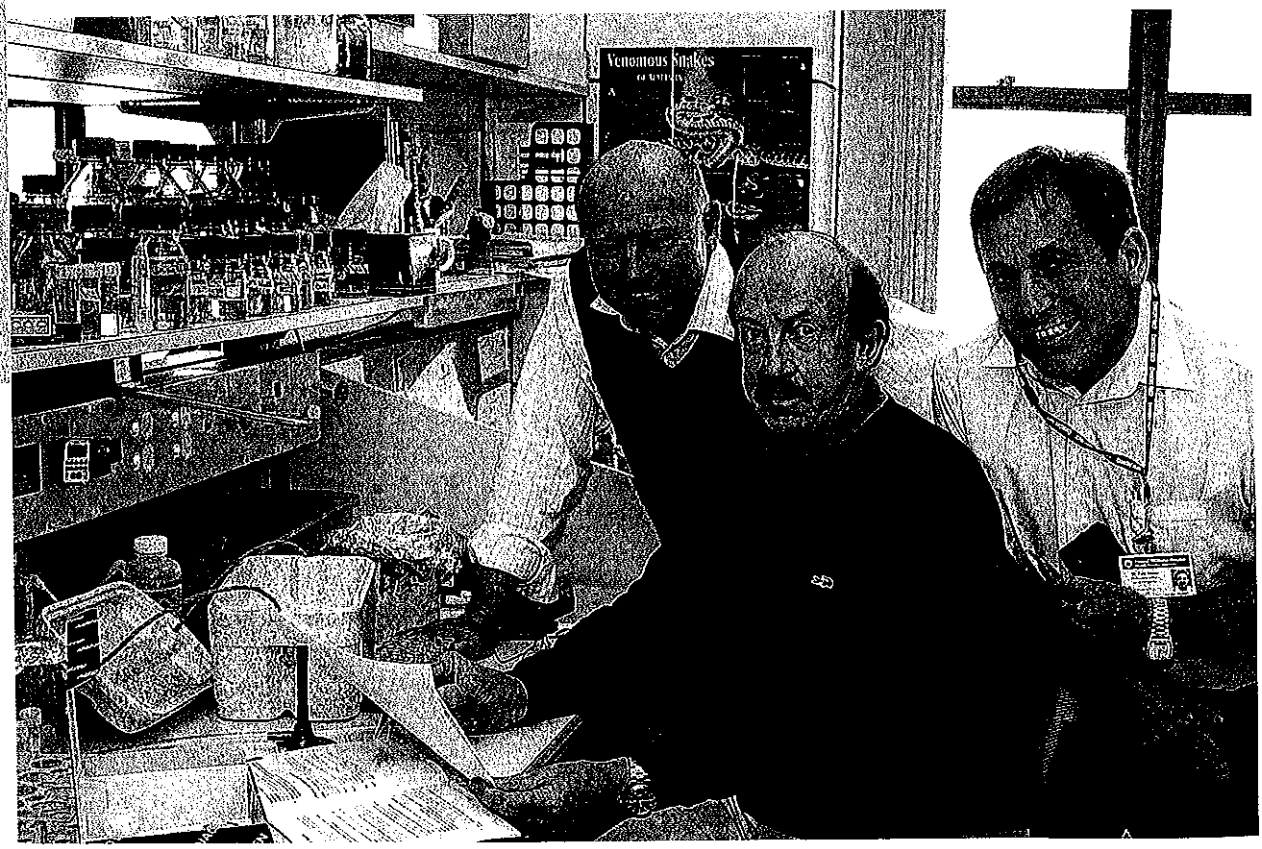


Blood cells clotting

A New Discovery

Dr. Masci started his new research by having venom glands removed from Australian brown snakes. He extracted the venom from the glands. Then he used the equipment in his laboratory to separate the different parts of the snake venom.

Dr. Masci found a chemical no one knew existed. This chemical found in the snake's venom makes blood clot quickly. It also stops plasmin from dissolving the clot. Why was finding this chemical such an important discovery?



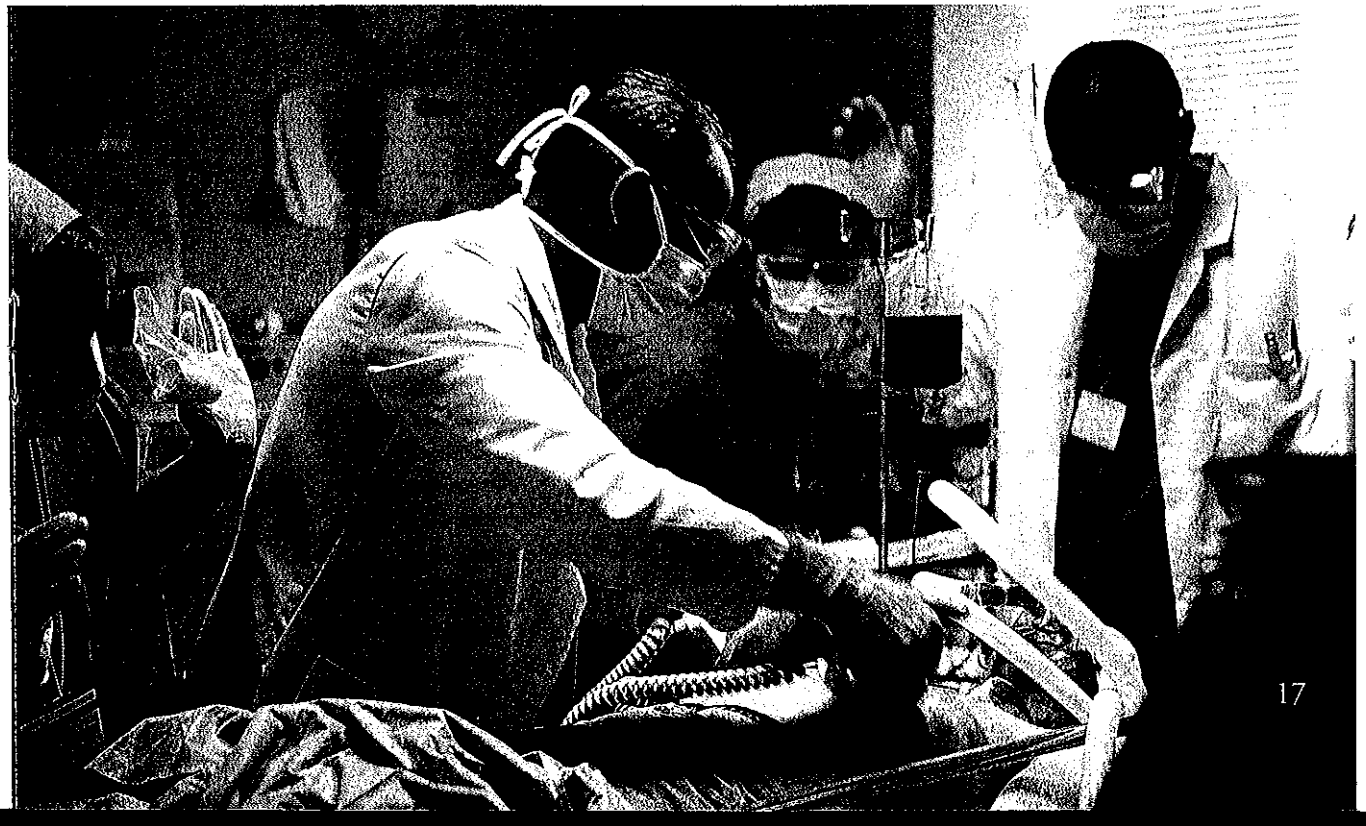
Dr. Masci (right) sits with his team: Martin Lavin (center) and John de Jersey (left).

Major wounds caused by surgery or accidents can cause a great deal of bleeding. Losing too much blood is dangerous. It can cause death. Dr. Masci thought the chemical he had discovered could be used to save people from bleeding to death.

Researchers are working with this chemical from the snake venom to create new medicines for accident victims. These researchers hope to use the chemical to make a cream or spray. It would be put right on a wound to immediately stop the bleeding.

An Australian brown snake's venom can be deadly, but one day, it may save many more people than it kills.

The venom of the Australian brown snake makes blood clot quickly. The venom of some other snakes stops blood from clotting. These other venoms may be used in new medications to treat heart attacks, which can be caused by a blood clot in an artery of the heart.

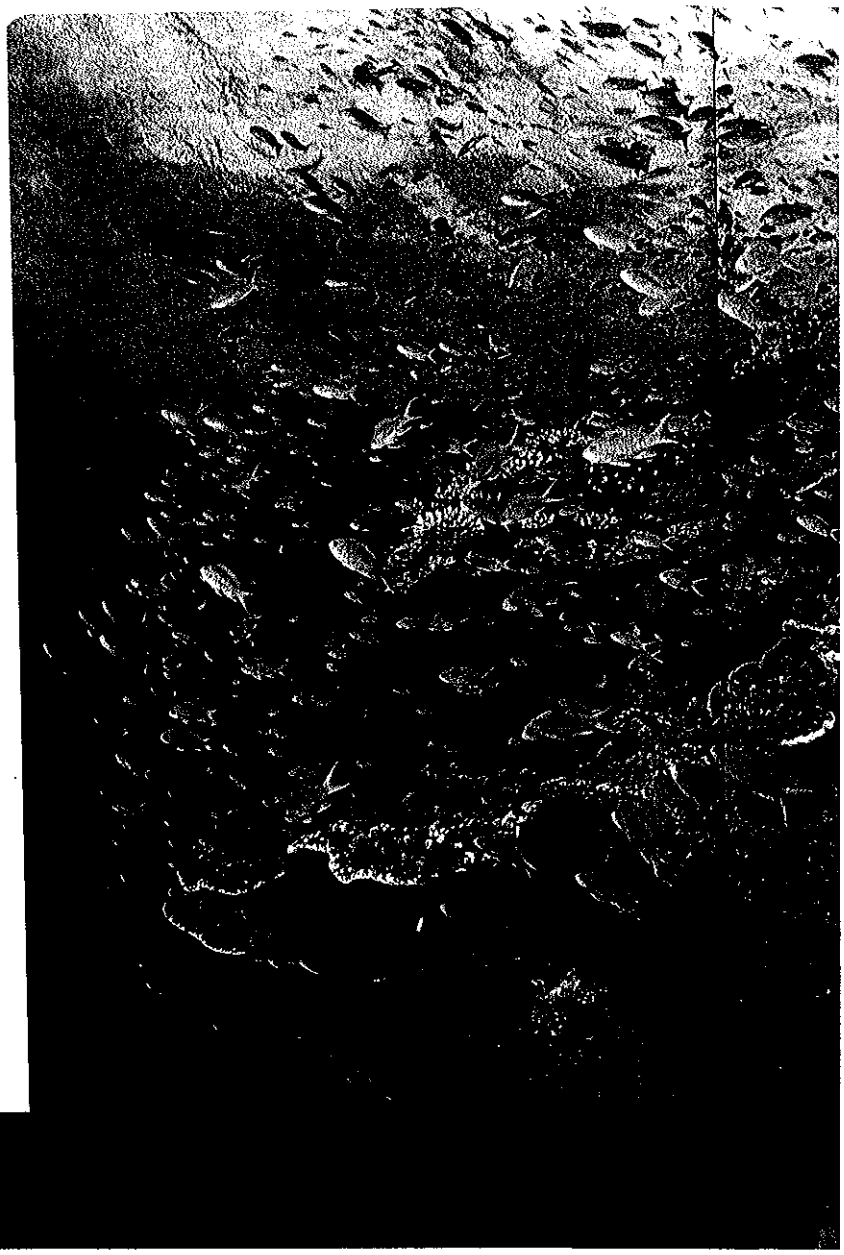


TOXIC STING

More than 50 years ago, a scuba diver was looking for shells below the ocean's surface. He scooped one up and slid it into a mesh bag. Then he headed for the surface.

On the way up, a sharp stinging pain seared his chest. A cone snail inside the shell had stung him through the bag and through his clothes! Soon, he started to feel sick and weak. The diver survived the sting. Others have not been so lucky.

Cone snails live in warm waters off the coasts of places such as Hawaii and Australia. They move very slowly, so they can't dash after their prey like many other animals. Instead, they shoot poisonous spears at their victims.

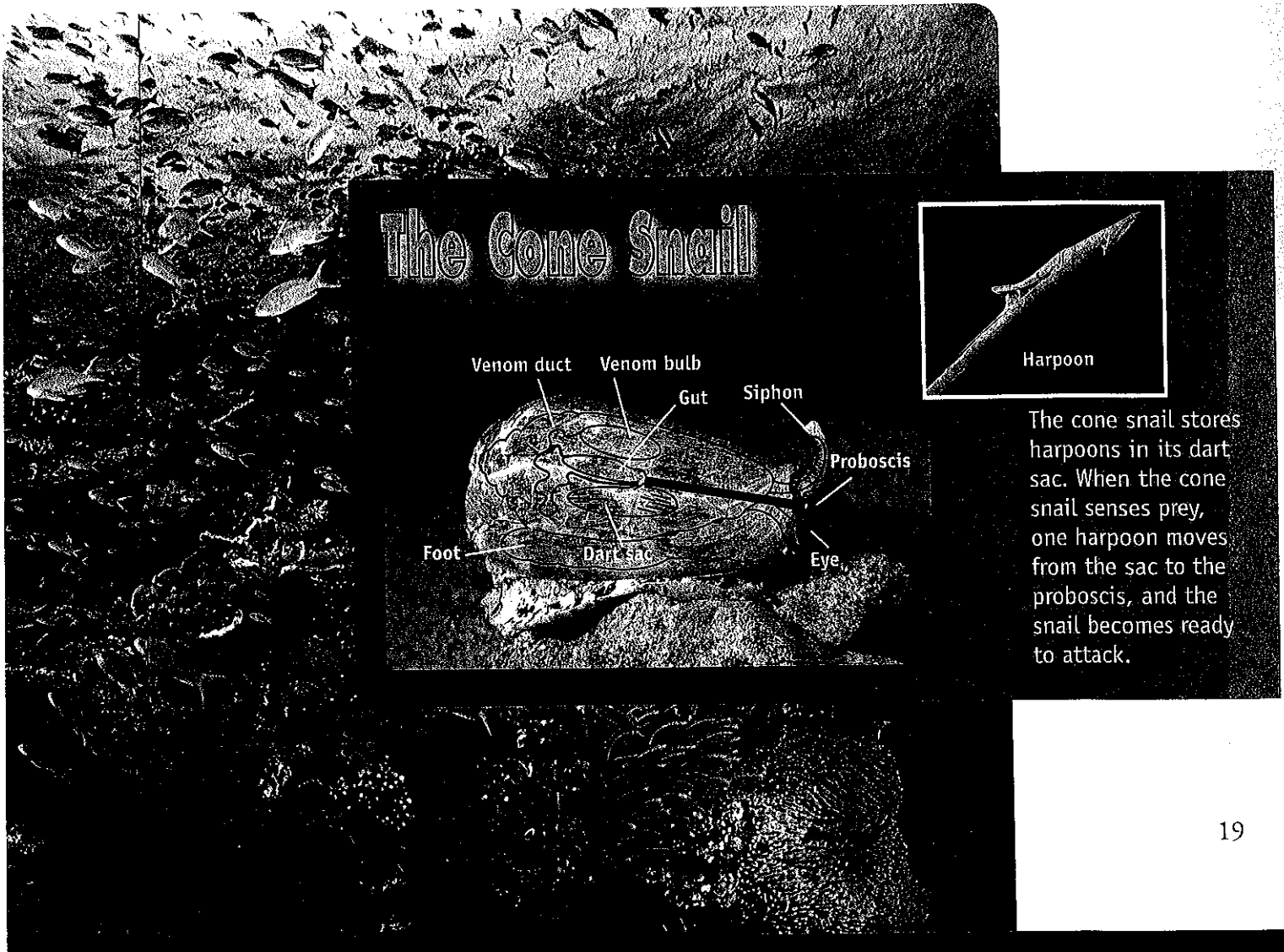


Scientists have found more than 500 different cone snail species in places like coral reefs and mangrove swamps around the world.

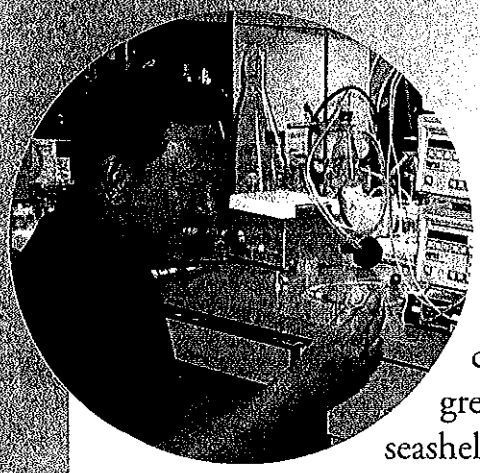
Inside every cone snail is a pouch called a dart sac. Inside the dart sac are "harpoons," which are like spears. Each harpoon has a sharp tip called a "tooth." The cone snail makes many of these tiny harpoons.

Sticking out in front of the cone snail are two noselike parts. The cone snail uses one to sense when fish or other prey is nearby. A single harpoon lies ready in the other. When the snail senses its prey, it jabs the harpoon directly into the victim, killing it.

Cone snail poison can also be very dangerous to humans. But as with the Australian brown snake, scientists have learned that cone snail venom can also cure.



The cone snail stores harpoons in its dart sac. When the cone snail senses prey, one harpoon moves from the sac to the proboscis, and the snail becomes ready to attack.



Researching the Deadly Snail

One scientist who is very interested in the cone snail is Baldomero Olivera. Dr. Olivera grew up in the Philippines. As a boy, he collected seashells. He knew that one kind of shell was home to a dangerous creature. Olivera had heard that the cone snail could kill people within a few hours of stinging them. When he became a scientist, he decided to do research on the cone snail. He was curious to find out why the cone snail's venom killed people. What was in the venom that made it deadly?

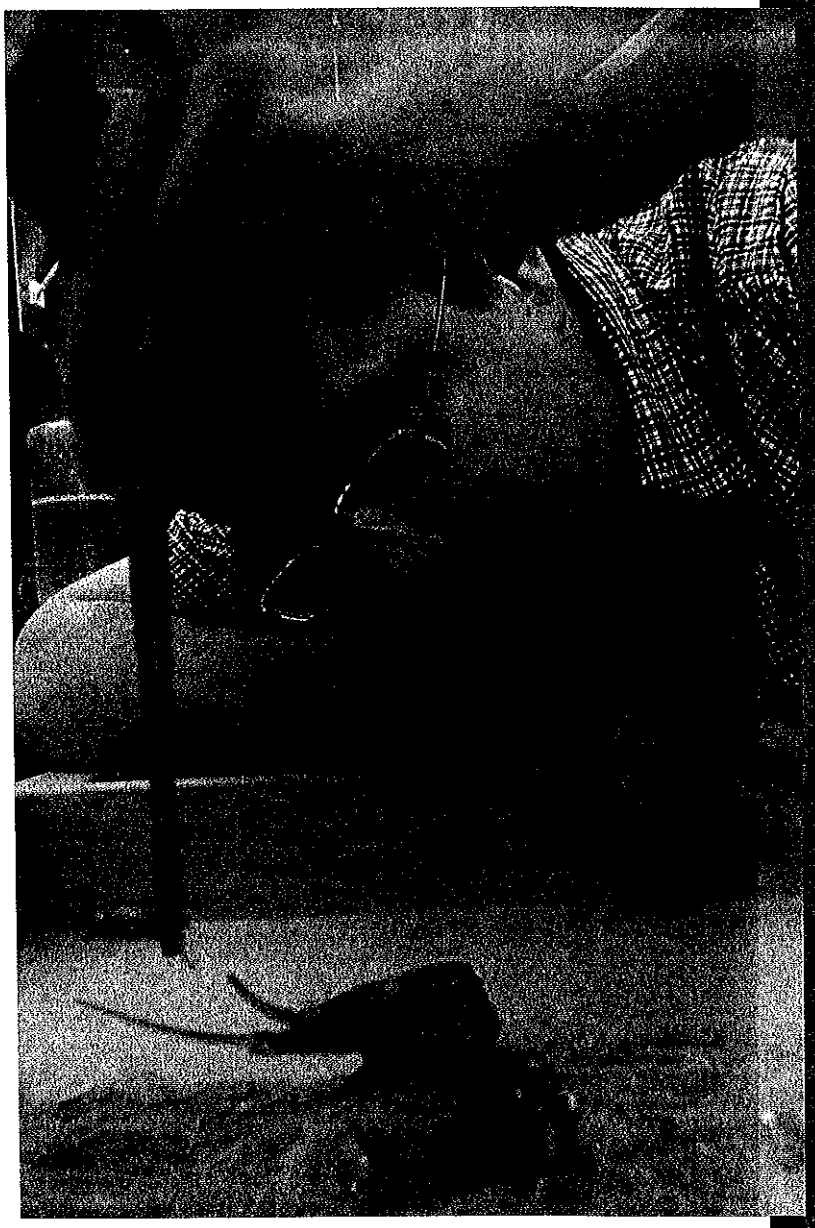
Dr. Olivera couldn't experiment on humans, so he began his research by injecting the cone snail venom into the stomachs of mice. The mice became paralyzed immediately. Dr. Olivera then tried to find the chemical in the venom that caused the paralysis, and he made a discovery. The cone snail's venom was made up of a combination of different toxins. After that, Dr. Olivera decided to stop studying the venom. He thought that there was nothing left to discover. He was wrong!

It can take as many as 10,000 cone snails to complete a single scientific study. Scientists have come up with ways to extract venom from live cone snails so they don't have to kill the snails to do research.

Collecting Venom

To get toxins from live cone snails, scientists must "milk" them. They do this by getting a snail to strike. Then they can collect the venom. Sound simple? It's not!

Scientist Jon-Paul Bingham has developed a special procedure for milking cone snails. First, he puts a tight rubber sleeve across the opening of a plastic tube. He uses **forceps,** which look like large tweezers, to hold a dead goldfish near the snail. And then he puts the tube behind the goldfish. When the snail strikes, it stabs through the goldfish and through the rubber sleeve, leaving behind its toxins inside the tube.



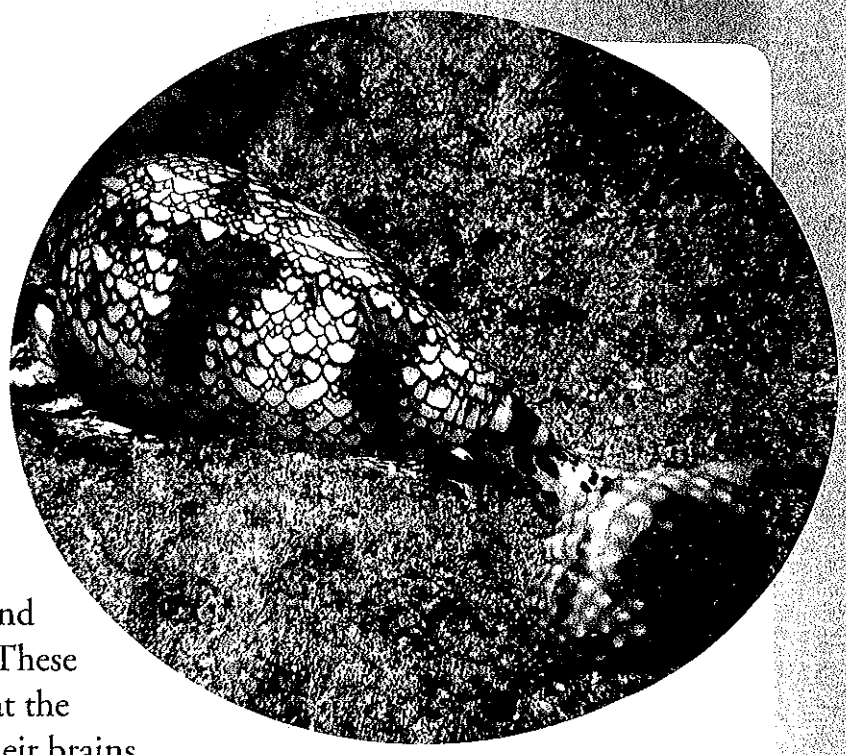
Jon-Paul Bingham milks toxins from a cone snail.

The Work Continues

A few years later, Dr. Olivera was working as a professor at the University of Utah. One of his students, Craig Clark, had a great question. He wondered what would happen if they injected cone snail toxins into a different part of a mouse's body instead of its stomach.

They decided to inject the poison into a mouse's **central nervous system.** The central nervous system is an animal's or human's brain and spinal cord. They also decided to separate the many toxins in the venom and give different toxins to different mice. The results were not at all what Dr. Olivera expected.

Many scientists are studying cone snails to try to find other possible medicines that might be made from the toxins. Dr. Barbara Furie, of the Marine Biological Laboratory at the Woods Hole Oceanographic Institution on Cape Cod, thinks the toxin might be used to treat patients whose blood does not clot properly.



Dr. Olivera realized that some cone snails can attack their prey just by releasing chemicals into the water. In this photo, a cone snail attacks another type of snail.

In Olivera's earlier experiments, the mice had just become paralyzed. This time, the mice reacted in many ways depending upon which toxin the scientists gave each mouse. Some of the mice shook, others scratched themselves, and some mice fell asleep. These behaviors suggested that the toxins were affecting their brains in different ways. Up until now, Dr. Olivera and his team had no idea that each toxin would cause its own reaction. Dr. Olivera was very excited.

This finding might not seem so important. But it was a major discovery for medical science. It meant that the cone snail venom would probably affect the human brain in many ways. Most important, some of these ways might be helpful.

Eventually, Dr. Olivera became one of the founders of a company called Cognetix. The company is doing research to develop medicines from the cone snail toxins. Once they find a specific cone snail toxin, the scientists **analyze** it to see what chemicals it contains. Then they can create an exact copy of the toxin. The scientists can keep doing their research with the **synthetic** toxins instead of toxin taken directly from a cone snail. That way, the researchers don't have to keep collecting cone snails to extract more and more venom.

From Shell to Medicine

Thanks to Dr. Olivera's discoveries, scientists now know that cone snail toxins affect the brain and nerves. To understand how this works, let's take a look at the nervous system. The human nervous system is like a set of roads for communication. Nerves communicate information to the brain through **electrical impulses** that travel along the "roads." The brain sends commands to the nerves along these "roads," as well. It tells the nerves to make muscles move or not move. The brain also determines whether a person does or doesn't feel pain.

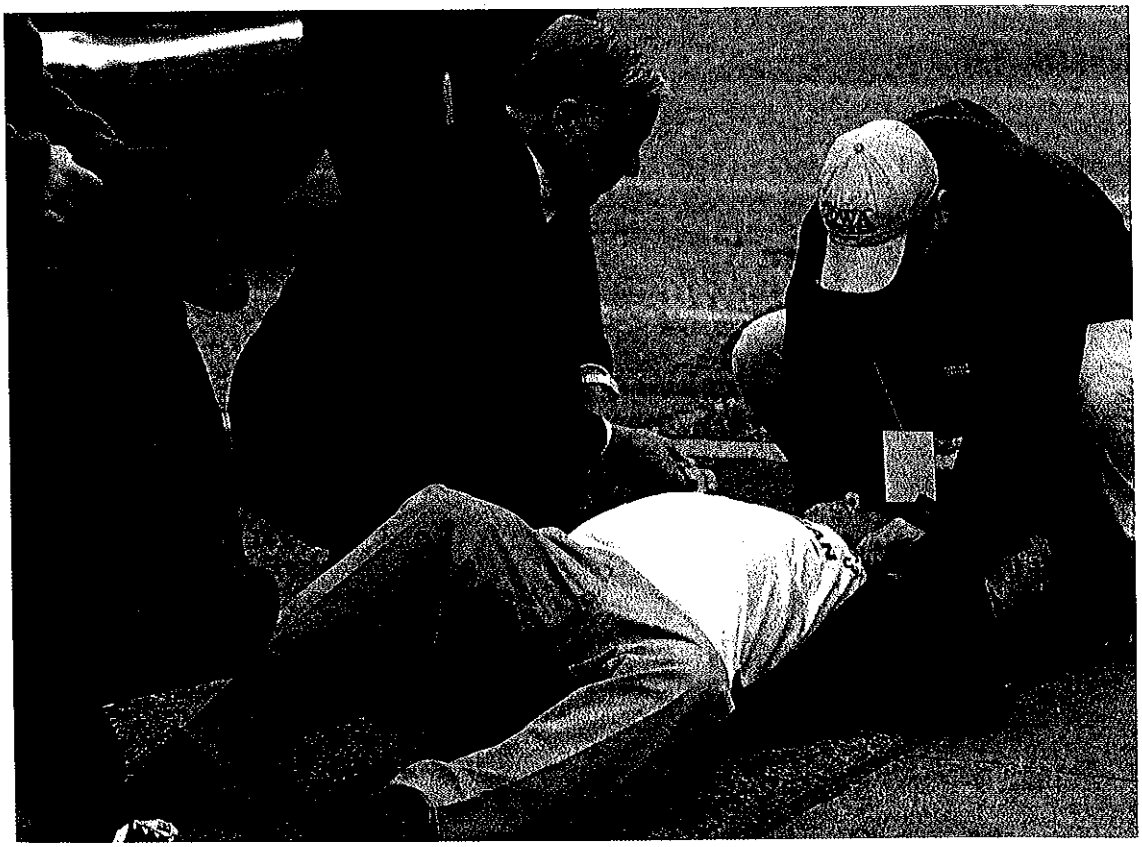
Scientists use **spectrometers** like this one to break venom down into different chemicals.

The medicine made from one of the cone snail toxins can put up roadblocks to stop some types of electrical impulses from traveling back and forth between the nerves and brain. These "roadblocks" can stop people from feeling pain by keeping the brain from receiving pain messages from the nerves.

Cognetix is currently testing a pain medication made from one cone snail toxin. This medication could change the lives of people with **chronic** pain—pain that never goes away. Most medications take away only a little of the pain. Scientists think medicine made from cone snail toxins will take away all of the pain.

Cone snails have a powerful sting, but when used in the right way, their venom may help people feel better instead of worse.

One cone snail toxin is being used to make a medicine for treating people who have seizures. The medicine would turn off the signal in the brain that causes seizures to start.



SCIENTISTS AT WORK

Dr. William Withering figured out that foxglove worked to cure dropsy. By experimenting and doing research with foxglove, he discovered how it worked. His work led to the development of digitalis, a lifesaving medicine for people with heart disease.

Dr. Paul Masci knew that the venom of the Australian brown snake killed people by making their blood clot. He analyzed the snake's venom to find out just how it worked. He reasoned that it could be used to cause clotting on purpose—and save people from bleeding to death.

Dr. Baldomero Olivera and his student just happened to try out something different in their laboratory. They didn't know what to expect, but their results led to a discovery that might help people who are in pain.

These three scientists worked in very different ways. But their results were similar. Each one found a way to use one of nature's toxins to cure rather than kill.

Today many scientists work in the rain forests, trying to find new plants and animals that may one day be useful in creating new medicines.

From Kill to Cure

The U.S. Food and Drug Administration (FDA) is a government **agency** that protects the safety and health of Americans. It **regulates** the food and medical drugs that are sold in the United States to make sure that they are safe for people to use.

When a scientist or a doctor discovers a potential new cure for a disease, the medicine isn't immediately available to patients. Before doctors can start prescribing it, the FDA requires that scientists perform careful studies on real people. These studies are called **clinical trials.**

Clinical trials are similar to what Dr. Withering did with foxglove, when he gave different patients different amounts and kept track of the results. Today, doctors test new medicines by giving them to groups of volunteers. Often one group of people receives the medicine, while another group receives a **placebo**—something that looks like the medicine, but is a fake. The volunteers are not told which group they are in. Researchers compare the effect a medicine had on the group who received the real medicine with the reactions of the group who received the placebo.

The Search Goes On

Scientists believe they have discovered only a small percentage of plants and animals whose toxins might be used in medicine. The search goes on for toxins that might help humans in many ways, from easing pain to curing cancer. And the future remains rich with possibilities.

Did you know that some people get stung by honeybees on purpose? That's because they believe the venom from a honeybee can take away some kinds of pain. The use of bee venom as therapy for pain is nothing new. Many civilizations of the ancient world, from Egypt to Greece to China, have practiced bee therapy. Bee venom was one of the *arcana*, or "secret cures," of Hippocrates, an ancient doctor known as the father of medicine.

The rosy periwinkle is not as toxic as the foxglove, but enough of it can be poisonous. When doctors in the 1950s were researching the plant, they made a great discovery: A chemical from the plant can be used to treat a kind of cancer called leukemia.

Hundreds of years ago, hunters in South America used the poisonous substance that oozed off the skin of dart frogs as weapons. These hunters collected the poison to put on the tips of their arrows. Today, scientists are discovering new uses for the dart frog poison. They think that, just as with the cone snail, the dart frog's poison might one day be used to make a powerful painkiller.

The Pacific yew tree is one of the slowest-growing trees in the world. But this poisonous evergreen is another powerful healer. Scientists have discovered that they can turn the bark and leaves of the yew into a cancer-fighting drug that people use today. However, it takes the bark of six mature yew trees—which means trees at least a hundred years old!—to treat one cancer patient.

Keep Going!

Here are some ways to share what you've learned, find out more, and develop your talents. Maybe you'll come up with some ideas of your own.

Think and Write

- Look back through the book and note the various plants and animals that protect themselves with powerful poisons. Write a guide for hikers and others about how to recognize and avoid these plants and animals. Include pictures and labeled diagrams to illustrate the text.

Dig Deeper

- What questions that you had before you read the book are still unanswered? What new questions came up in reading? You can start looking for answers at these Websites. Write down your answers and tell where you found them.

NATURE: The Venom Cure
www.pbs.org/wnet/nature/venomcure

NATURE: Victims of Venom
www.pbs.org/wnet/nature/victims/index.html

How Animals Can Save Us: Creepy Crawly Healers
www.healthscout.com/printer/1/8007375/main.html

Update

- Use the Internet or the library/media center to find information about toxins used for medicine today. A suggested Website is:
news.nationalgeographic.com/news/2005/06/0614_050614_snaildrugs.html

Online Presentation

- You have read how toxins can be powerful allies in the treatment of illnesses. Create an online presentation, using PowerPoint, iWork Keynote, or other software, describing the benefits of each toxin discussed in the book. Be sure to include photos of the plants, insects, and animals and any diagrams needed to make your points.

Glossary

active \ak′ tiv\ *adj.* capable of acting

agency \ā′ jən(t) sē\ *n.* a division of the government that has a particular task

analyze \a′ nə līz\ *v.* study carefully, often for a scientific purpose

antivenom \an tē ve′ nəm\ *n.* a substance that is able to neutralize the poisons of a venom

central nervous system \sen′ trəl nər′ vəs sis′ təm\ *n.* the brain and spinal cord of a human or other animal. The central nervous system controls the activity of the entire nervous system.

centrifuge \sen′ trə fyüj\ *n.* a machine that uses centrifugal force, or force pushing out from the center, to separate substances

chemical \ke′ mi kəl\ *n.* a substance obtained through the processes of chemistry, the science that deals with the composition and properties of substances

chronic \krä′ nik\ *adj.* lasting a long time

clinical trial \kli′ ni kəl trī′ əl\ *n.* a scientifically controlled study that tests the usefulness and safety of a new medicine

clot \klät\ *v.* thicken from a fluid to a more solid mass

deduction \di dək′ shən\ *n.* the act of coming to a conclusion based on available evidence

edema \i dē′ mə\ *n.* an excessive buildup of fluid in the blood vessels and tissues

electrical impulse \i lek′ tri kəl im′ pəls\ *n.* a current that runs through the nerves carrying information to and from the brain

extract \ik strakt′\ *v.* draw out by a physical or chemical process

folk medicine \fōk′ me′ də sən\ *n.* a form of medicine that arises from cultural traditions and beliefs. Folk medicine often includes plant-based remedies based on observation and experience.

forceps \for′ səps\ *n.* an instrument used for grasping and holding objects, especially in delicate operations

paralysis \pə ra′ lə səs\ *n.* the loss of the ability to move

placebo \plə sē′ bō\ *n.* a substance that has no medicinal effect. A placebo is used in controlled experiments testing whether another drug works properly.

plasmin \plaz′ mən\ *n.* a substance in the blood that breaks down the protein in blood clots

receptor \ri sep′ tər\ *n.* a group of cells that receives information from the environment, such as sound, heat, or texture

regulate \re′ gyə lāt\ *v.* bring under the control of law

seizure \sē′ zhər\ *n.* an abnormal release of electrical signals in the brain that often causes violent shaking

spectrometer \spek trä′ mə tər\ *n.* an instrument that separates something, such as light or particles, according to some property, such as wavelength or mass

synthetic \sin the′ tik\ *adj.* manufactured by a chemical process. A synthetic substance is made to imitate something in nature.

toxin \täk′ sən\ *n.* a poisonous substance made by a living thing

toxinologist \täk sə nä′ lə jist\ *n.* a scientist who studies poisons produced by living things

Pronunciation Key

\ə\ **a**mong \ər\ m**ur**der \a\ **a**sk \ā\ **a**pe \ä\ h**o**p, c**a**r \ch\ **ch**op \e\ **e**nd \ē\ gr**ea**sy \g\ **g**et \i\ h**i**d \ī\ **i**ce \j\ **j**et \ŋ\ ki**ng** \ō\ n**o** \ô\ s**aw** \oi\ t**oy** \oo\ b**oo**k \ou\ **ou**t \th\ **th**ank \t͟h\ **th**en \ü\ b**oo**t \y\ **y**ou \zh\ A**s**ian