Getting the Le

ead Out

MATTHEW GILSON

"The ultimate high is making a new discovery."

Hilary Godwin is a chemist at Northwestern University near Chicago. Godwin studies the chemistry of lead poisoning.

By Karin Jegalian

Ask Hilary Godwin about her childhood summers at camp, and you might be surprised by what you hear.

For Godwin, summer camp meant hiking the mountains of northern California and helping her dad collect snakes. Her father, along with her stepfather and stepmother, is a herpetologist—a biologist who studies reptiles or amphibians.

Scrambling around outside, watching animals in action, Godwin saw, up close, how scientists work. Her efforts even earned a mention in the small print at the end of some of her father's research papers.

As a child, it didn't occur to Godwin, now 37, that she would be anything other than a scientist when she grew up. She knows that's not the case for everyone, yet she thinks most people can appreciate science even if they do not pursue it as a career.

Although many people see science as a bunch of facts, Godwin says, that's not really accurate.

"[The facts] are not what excite most scientists. It's the sense of discovery and the challenge of the unknown."

To Godwin, excitement is the essence of science, and that's the main lesson she tries to teach to her students.

"The ultimate high is making a new discovery or thinking you might have made one," she says.

Field Work at Home

Today, Godwin tries to re-create in her own lab some of the excitement that filled her summers years ago. In addition, each year the chemist at Northwestern University, located just outside Chicago, runs an intensive summer science workshop for incoming freshmen.

The experience is designed to get the students doing research. They collect soil and water samples and test them for the presence of heavy metals like lead. Godwin has discovered that looking at real-life problems that affect people in the community really inspires her students.

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Undergraduate students working in Godwin's lab get a real taste for research.

"One of my favorite parts of this program is taking the students out into the local community to gather samples. This is the closest I come to doing 'field work' as an adult."

From the very beginning, Godwin saw that science could be thrilling and fun. To her, research is more than solving puzzles, it's finding new puzzles to solve.

Her personal puzzle is the mystery of what makes lead act as a poison when it gets inside a person's body, especially if that person is a young child. Godwin has been studying why lead is poisonous for more than 8 years, ever since establishing her own lab.

Good-for-Nothing Lead

By tracking atoms of lead inside cells, Godwin hunts down which molecules—particularly proteins—pick up the lead that finds its way into the body. In doing so, she hopes to explain how lead exposure can contribute to health problems such as learning delays in children.

Believe it or not, some metals are perfectly safe to ingest, albeit in very small amounts (see sidebar on page 13). In fact, several metals are required for good health. Glance at the label of a multivitamin bottle and you'll see some of these listed.

Metals such as calcium and iron are important dietary staples. We also need zinc, copper, and potassium, in addition to tiny amounts of other metals such as selenium, manganese, and cobalt.

Often, metals work along with the body's enzymes to help these molecules do their job of speeding up chemical reactions. Our bodies couldn't function without enzymes, and many enzymes are helpless without metals.

All bets are off for lead, however.

"There's nothing good about lead," says Godwin, explaining that no one has dug up any evidence that lead does anything useful in the body.

While some pediatricians say there are no safe levels of lead, especially in young children, most of us do have trace levels of it because lead is all around us. For thousands of years, lead was part of many products, from eating utensils to ink. Before 1978, it was also a component of house paint. This poses a health hazard for children living in older homes, since they can suffer lead poisoning by eating or touching chipped or peeling paint. Lead dust can contaminate toys and other household objects.

In addition, until the mid-1980s, lead was added to gasoline to aid combustion. While gas stations no longer sell leaded gas, residue from fuel used years ago is present in soil in some areas, especially next to roads and highways.

Lead, which is sometimes present in chipped or peeling paint in houses built before 1978, is a health hazard.

Lead dust in soil can settle on clothes and shoes or become airborne. Lead used in plumbing, often to seal pipe joints, contaminates some water supplies, especially in neighborhoods with older homes.

Once lead gets inside the body, it can hurt virtually every organ but seems to do the most damage to the developing brain and nervous system.

Doctors worry most about the effects of lead on fetuses, babies, and young children because their bodies are growing so quickly. Often, the first symptom of lead poisoning in children is high blood levels of the metal found during routine testing. Ironically, such routine testing showed that Godwin's own son, who is now 3 years old, had high levels of lead in his blood at one point.

Godwin (bottom and top, right) started field work as a child, spending summers at "snake camp" with her father and twin sister, Laura (top, left).

"It brought home to me how helpless you can feel as a parent," she says, adding that her 1920s-era home, while charming, nevertheless harbored the hidden health risk of exposure to leaded paint.

In addition to taking the necessary steps to reduce lead exposure in her home, Godwin decided to get certified as a lead risk assessor, a person who is licensed to find lead hazards in buildings.

A Chemist is Born

Growing up amid so many biologists—in addition to the herpetology crowd, Godwin's mother researched ants and now teaches biology—you would think Godwin was destined for a career in biology.

In fact, at one point she dreamed of studying chimpanzees and being the next Jane Goodall. A famous primatologist, Goodall pioneered the study of chimpanzee behavior in the wild, beginning in the 1960s.

But Godwin ended up a chemist, lured by the fascination of making her first molecule from scratch. After taking a few social science courses in college at the University of Chicago, then joining a research lab in the school's chemistry department, Godwin found that she felt more at home with chemistry, a quantitative, measurement-based field of study.

She earned a Ph.D. in chemistry at Stanford University in Palo Alto, California, and by the time she graduated, she already had a job offer to run her own lab at Northwestern. But first, she decided to spend a few years as a postdoctoral fellow at Johns Hopkins University School of Medicine in Baltimore, Maryland.

While there, Godwin learned of work done by other scientists showing that lead can slice through RNA, a major type of genetic material in our bodies. Could this explain why lead is poisonous, she wondered? Godwin read up on the topic and realized that, in fact, no one really knew what makes lead toxic.

An Uncommon Bond

According to the Centers for Disease Control and Prevention, 2.2 percent of children in the United States between the ages of 1 and 5 years have blood levels of lead greater than or equal to 10 micrograms per deciliter. This

HILARY GODWIN

amount has been linked with harmful health effects, in particular learning disabilities and behavior problems.

Until the last decade, very little was known about why this particular metal is so harmful. Godwin and other researchers have begun to sleuth the molecular mystery. Her research has shown that lead interferes with the function of proteins that turn genes on or off. She has discovered that lead usually does its dirty work by displacing atoms of zinc and calcium in these proteins.

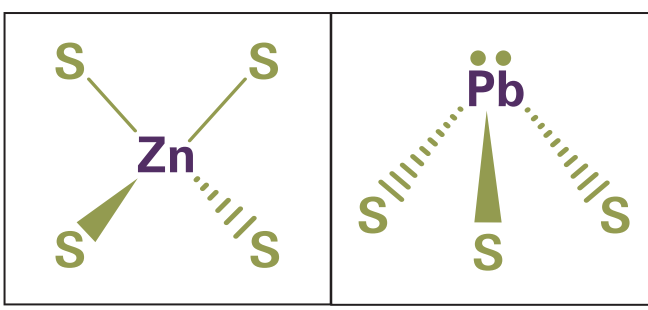
Zinc displacement occurs even with relatively low levels of lead in the body, Godwin says. With lead in zinc's place, the proteins can't do their jobs properly.

A protein's precise shape is crucial to what it does, and even a subtle disruption can affect its function. When lead takes the place of zinc, the protein's shape changes. This is because lead forms different chemical bonds than zinc does. Zinc forms four, equally separated chemical bonds, while lead forms three, and these are at different angles (see drawing).

Researchers in Godwin's lab measure how tightly proteins bind to lead and other metals. One of the experiments they do is to test a certain protein's vulnerability to the effects of lead. In such an experiment, Godwin mixes a protein sample with lead and another metal to which the protein normally binds. If the lead sticks more tightly than the other metal, it's a hint that the test protein will be affected by lead, she explains.

For example, some zinc-binding proteins in the body are known to be crucial for normal development in children and for maintaining proper blood pressure in adults. Lead in place of zinc in these proteins can cause developmental delays in kids and high blood pressure in adults. Lead also knocks out zinc from a protein that helps form molecules of heme, which, among other things, carries oxygen in the blood. This snag may explain why lead can cause anemia, or low levels of red blood cells.

Lead also takes the place of zinc in a protein involved in making sperm, perhaps accounting for increased infertility rates in men exposed to high levels of lead at work. And when atoms of calcium in the body are bumped out by lead—which happens when lead levels are quite high—nerve impulses get messed up. Because of the way cells amplify electrical signals, just one lead-corrupted protein can have a significant effect.



Zinc (Zn) and lead (Pb) each form a different pattern of chemical bonds. In place of zinc, lead can twist a protein's shape and interfere with how the protein does its job in the body.

Pioneering Spirit

Godwin loves science and working in the lab, and she thinks the experience is important for nearly everyone. It's not that she wants to turn everyone into a scientist, but Godwin says that doing research is the best way to understand how science works. She wants students to experience science as scientists do.

Although students routinely learn about "the scientific method," they rarely do so while actually exploring something for themselves, Godwin points out. She wants to create teaching experiences that mimic true discovery instead of just telling students that science is *about* discovery. Students who get a real taste of research may not decide to make a career of it, but she thinks they will certainly be better informed in public discussions about science.

Throughout her life, Godwin has been exposed to unusual experiences and pioneering ways. As the first woman chemistry professor at Northwestern, she is mapping a course for other women in science.

Recently, Godwin achieved another first when she was appointed chairperson of the entire chemistry department. She is the first woman to hold the post.

In this capacity, Godwin is eager to help young faculty with their careers—to make sure that these researchers are able to balance work and family life, and to help them learn to be managers and mentors as well as scientists.

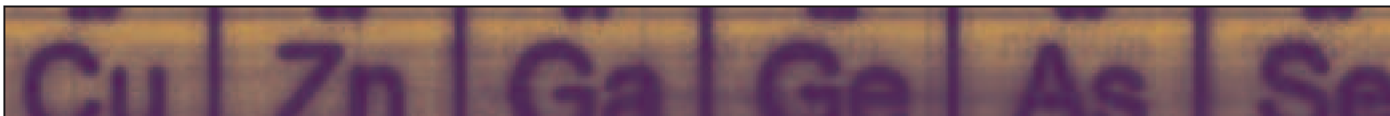
Godwin calls chemistry, like other fields that depend on hands-on work, an "apprenticeship science." Students and postdoctoral researchers do much of the work, and professors act as trusted advisors.

Second only to the thrill of discovery, what Godwin likes best about being a scientist is mentoring young people. She says that being a scientist is not just a career, it's a way of thinking. Godwin believes that growing up with scientists affected how she thinks and how she views the world, and it similarly affects how she is raising her son.

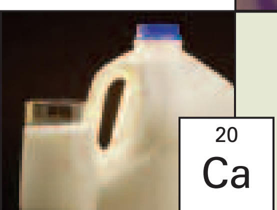
In her home, questions abound and everything is a potential experiment. The kitchen counter doubles as a lab bench where the materials and variables can be munched when the experiment is done.

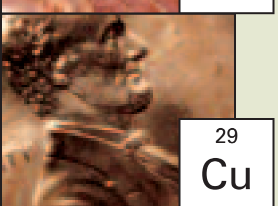
Family vacations are an opportunity to get out "in the field," for example, by scuba diving or watching animals in their natural environments.

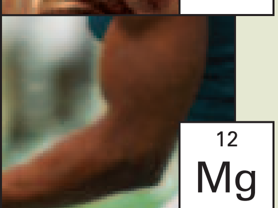
Or hunting for snakes in the mountains…now a Godwin family tradition. ■



Healthy Metals







Lead is bad for you, but many metals are vital to life. Some of these "good metals" are listed below. Cells usually need them in just miniscule amounts.

[Ca] Calcium. Did you know that this essential component of bones and teeth is a metal? In our bodies, calcium is abundant in bones and is critical for proper muscle and nerve function. Good dietary sources include dairy products, broccoli, figs, and sardines.

[Fe] Iron. Iron is not only found in skyscraper steel and frying pans, it is also in the bloodstream. Iron from foods like meat, beans, and spinach helps carry oxygen throughout our bodies.

[Cu] Copper. The metal copper is found in old pennies, high-quality plumbing, and electrical wires. It's also in lobster, crabs, beans, and nuts. In our bodies, copper helps mop up dangerous "free radicals," highly reactive chemicals that have been linked to an increased risk of cancer and heart disease.

[Mg] Magnesium. Magnesium is a metal used in flares and fireworks. Our bodies need magnesium for strong bones and teeth, as well as for muscle contraction and relaxation. Food sources include vegetables, especially dark green, leafy ones.

[Zn] Zinc. This metal is present in a range of household products, from batteries to cosmetics. In our bodies, many proteins need one or two zinc atoms to fold into the right shape. Zinc is important for controlling gene activity and regulating hormones. Good dietary sources include oysters, chick-peas, whole grains, and nuts.

[Co] Cobalt. Mixed with other metals, cobalt is used in jet engines. It also gives a brilliant blue color to pottery, glass, and tiles. Cobalt forms the core of vitamin B12 and is important in the body for making red blood cells. This metal is found in meat, dairy products, and leafy green vegetables.

[Mn] Manganese. This metal helps to give Sacajawea dollar coins their shiny, golden luster and amethysts their purple hue. In our cells, it helps break down fats, carbohydrates, and proteins to convert food into energy. Manganese is present in whole grains and cereal products.—*K.J.*