



Up Close With

Marc Zimmer

COMPUTATIONAL CHEMIST

“Chemistry is a bit like a language. The best way to learn it is to immerse yourself and get involved in a research project.”

CAREER ALTERNATIVE

Game warden

BEST ADVENTURE

Hitchhiking across Africa

FUTURE GOAL

Publishing a novel

LIKES TO READ

**Trashy novels,
South African history**

BOB MACDONNELL



Green Light

BY EMILY CARLSON

On a moonless November night, when the water shined brighter than anything in the sky, a group of college students kayaked off the coast of Puerto Rico. As the students scooped their paddles through the water, stringy threads of light appeared beneath their boats.

Shuang Song, one of those students from Connecticut College, pulled her hand through the crystal clear water, leaving a wake of whitish-blue light. Like a shadow, the glow followed the boats across the bay.

The experience left the students in awe—of science. At the heart of this light show was a chemical reaction that caused tiny creatures in the water to flash blue when disturbed by nighttime boaters or swimmers.

The students already knew this. During the months leading up to the excursion, they had taken a chemistry class called “Glow,” where they learned about molecules that light up organisms in a rainbow of colors.

“We learned a lot about dinoflagellates before going on that trip,” says Song. “So it was really cool to see them in person.”

For Marc Zimmer, the students’ chaperone and teacher, the exotic field trip achieved its goal. It showed his students that learning science isn’t just about reading textbooks or listening to lectures—it’s about doing.

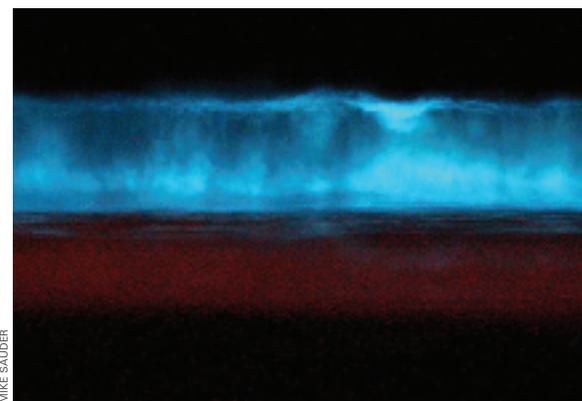
Just Doing It

Unlike his students, Zimmer learned this lesson the hard way.

Growing up in a small, industrial town in South Africa, Zimmer enjoyed hiking into the mountains and seeing rhinos, buffalo and lions. His mother wanted him to become a doctor, but Zimmer had other plans. He wanted to be a game warden.

He imagined spending his days tending to big game—protecting them from the dangers of disease and poaching—and his nights listening to their wails across the wilderness. “There was a freedom associated with being a warden,” he says.

So when Zimmer went to college, he took the first step toward pursuing his dream: He planned to major in biology and get a game warden certificate. But he hit a few snags.

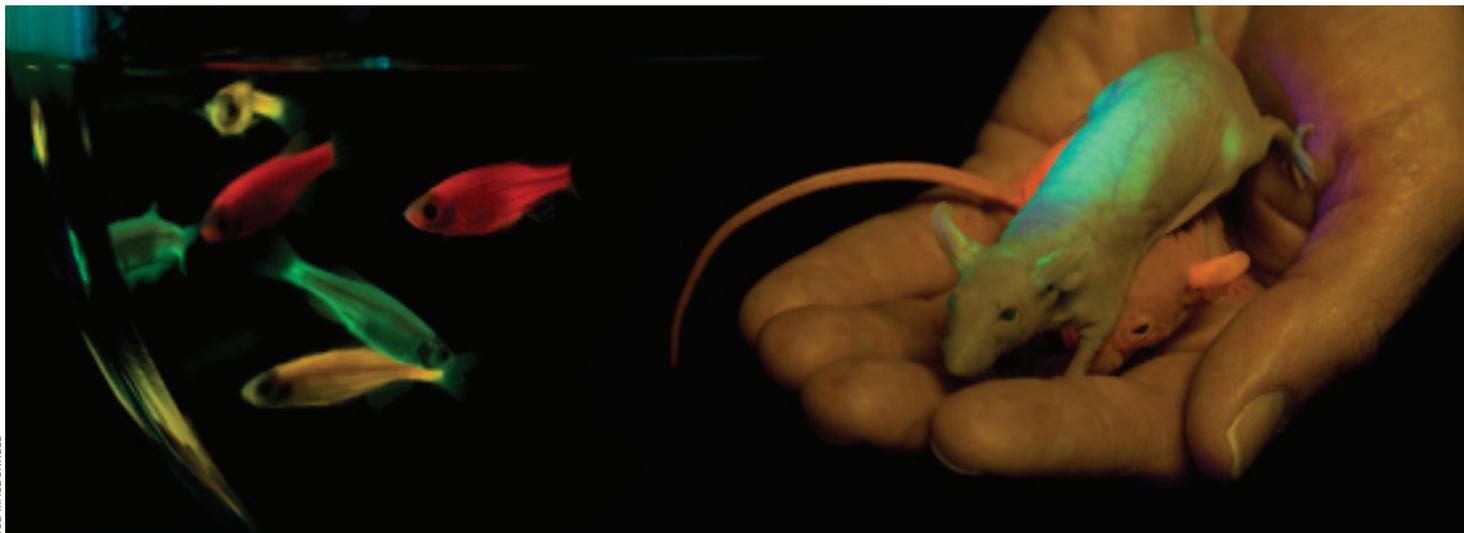


MIKE SAUBER

As waves crash along the shore, tiny creatures called dinoflagellates glow blue in the water.



We can see things on the computer that we can't



BOB MACDONNELL

Zimmer's family pets glow in the dark in response to ultraviolet light.

For starters, he flunked his required botany class because, he says, his teacher was “incredibly boring.” Next, he took a required chemistry course. To his surprise, the course opened up a world of molecules just as vast and magnificent as the African savannah. Zimmer switched majors.

Studying molecules, says Zimmer, offered the same adventure as studying how an infection might spread through a giraffe population. “Both require detective work,” he adds.

But there was still a major difference: location. Instead of learning in the lab—or, as a warden-in-training, in the bush—Zimmer sat in large lecture halls and listened to professors talk about science.

“I was given a lot of material in a pretty dry format and told to learn it,” recalls Zimmer. It wasn't until

he got involved in research projects that he excelled—and realized the importance of hands-on learning.

Now 47, Zimmer uses computers to study the protein molecules that help jellyfish glow in the dark. And he makes sure he gets his students into the act as early as possible.

Recalling his own experience, he says, “I think you have a much better chance of getting students to learn something if they can see the relevance and the excitement and the fun of it.”

That's especially true for students enrolled in Zimmer's 8 a.m. introductory chemistry course.

To keep the students awake, Zimmer performs all sorts of loud and colorful chemistry demonstrations. He blows up hydrogen balloons and makes foam fountains, which he claims were one reason he majored in chemistry.

But the real show-stoppers are his family's pets—two mice and a bowl of zebrafish.

When Zimmer turns off the lights, his show begins. Under an ultraviolet light, the white mice glow green

and red, and the fish go from gray to bright orange or yellow. Geneticists engineered these animals to have fluorescent proteins in their cells, a harmless process that entertains (and educates) students.

Zimmer uses the animals to teach another popular early-morning class, “Glow.”

It Glows

The glowing pet tricks help Zimmer explain his research on bioluminescence, a natural phenomenon in which living organisms convert chemical energy to light energy.

Many species have this capability. Most are marine organisms, but some—like the firefly and the glow-worm—live on land. They fluoresce for many different reasons: to spook predators, lure prey, attract mates and even communicate.

For centuries, fishermen off the west coast of North America noticed that some of the jellyfish gleamed in the water. When researchers took a closer look, they found small organs along the rim of the jellyfish that sparked green pinpricks of light.

According to Zimmer, the scientific story of bioluminescence is just as

FIND MORE

Watch jellyfish glow

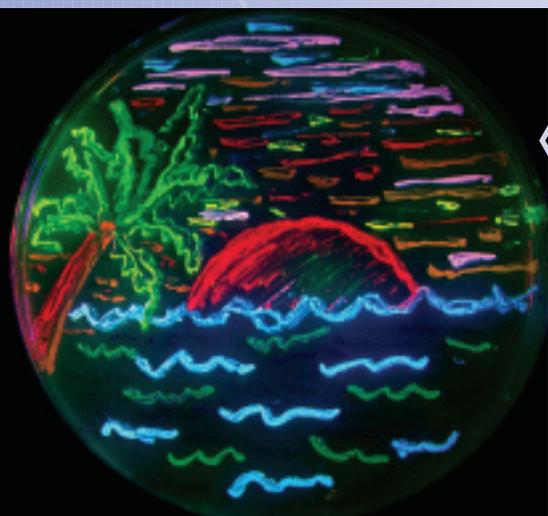
<http://www.nigms.nih.gov/findings>





The Oscars of Chemistry

Like a kid on Christmas morning, Marc Zimmer woke up in sheer excitement on October 8, 2008. Before dawn, he logged onto his computer to watch a live video feed from Stockholm, Sweden, announcing the 2008 Nobel Prize in chemistry.



On that fall morning, the Nobel Foundation broadcast that the chemistry prize would go to Osamu Shimomura, Martin Chalfie and Roger Tsien for “the discovery and development of the green fluorescent protein (GFP).”

Considered the pinnacle of scientific achievement, Nobel Prizes honor discoveries in different fields that have profoundly changed the way we think and live.

Zimmer had a hunch that the 2008 chemistry prize might go to the GFP discovery. Considered an expert on the topic, Zimmer had been contacted by the Nobel Foundation months before the announcement to give the committee details about GFP and groundbreaking research on it.

(Shhh...Zimmer can't share the specifics for 50 years!)

Zimmer was not among the winners (he didn't expect to be), but nonetheless the prize put his field of research in the international spotlight.

And for Zimmer, the news got even better. As a GFP historian and scientist, he was invited to attend the lavish award ceremony in Stockholm. He hob-knobbed with Nobel laureates, met Swedish royalty and ate new foods like reindeer pâté.

In an article he wrote about the trip, Zimmer reports, “The fact that GFP was the basis of a Nobel Prize in chemistry, and that I could be part of the excitement associated with its award, was a dream come true.”—*E.C.*

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Because the discovery of GFP has led to so many potential applications, it was honored with the 2008 Nobel Prize in chemistry (see “The Oscars of Chemistry,” left).

Making Light of Things

Zimmer has spent the last 15 years studying GFP in his computer lab at Connecticut College. He's most interested in the protein's three-dimensional structure.

Shaped like a soda can, GFP is made up of 238 amino acids. Just three of these amino acids come together in the center to form the chromophore—the protein's light source (see image, page 5).

Zimmer wants to know, step-by-step, how this part of GFP helps the protein give off green light. To do this, he uses computers.

“We can see things on the computer that we really can't see in real life because they occur too fast,” he explains.

From start to finish, the chromophore takes its unique shape in about an hour. Compared to other molecular processes, this is pretty slow. But Zimmer says it's still too fast for traditional structure determination methods.

So Zimmer uses information about other fluorescent proteins to calculate each twist and turn of GFP's chromophore formation. This precise sequence, he says, could eventually allow researchers to turn fluorescent proteins on or off whenever needed.

Zimmer is also using this structural information to design brighter proteins, particularly ones that glow red. Unlike other colors, shades of red give off the lowest amount of energy, making these proteins much safer to use in living tissues.

Reds also have the longest wavelength, which means they can

lead to different approaches to problem solving.

penetrate deeper and still be visible. That's why you see only red light when you hold your hand over a flashlight—the colors with shorter wavelengths get absorbed by your flesh.

In addition to improving the properties of fluorescent proteins, Zimmer is studying the structure of a bioluminescent protein found in corals as well as the one that turns fireflies into beacons of light.

Science Club

While many scientists spend their research careers studying just one aspect of fluorescence or one particular protein, Zimmer bounces from project to project. It's partly because he likes to work on many things at once: He's often on the computer, watching TV and listening to music at the same time.

But there's another reason. Zimmer sets up smaller, shorter studies to get students involved in research.

Some of his students work in the lab for class credit during a school semester, while others get paid for it during the summer. Students can make up to \$3,500, but they must work 9 hours a day for 10 weeks. Most of the student projects focus on GFP and other fluorescent proteins.

Zimmer works closely with the students, especially in the beginning, to make sure they're familiar with the basic concepts and equipment. Some students think Zimmer lives on campus, just like them, because they can always find him in class or in his lab or office.

"There has never been a time when I tried approaching Marc and he wasn't there," says sophomore Rabia Nasir. For two and a half hours each week one semester, she downloaded structural details about many different types of fluorescent proteins to compare and modify them.

Senior Luisa Dickson has spent two "intense" summers working in Zimmer's lab, where she calculated specific measurements for more than 1,000 GFP molecules. "Even though this sounds tedious," she says, "I enjoyed every moment."

Her work paid off in other ways, too. The findings contributed to two larger studies on the GFP chromophore structure that were described in scientific journals, making this undergraduate a published author.

And she's not the only one. Of the 56 students who have worked with Zimmer, 34 have co-authored publications and 35 have presented talks or posters at scientific meetings.

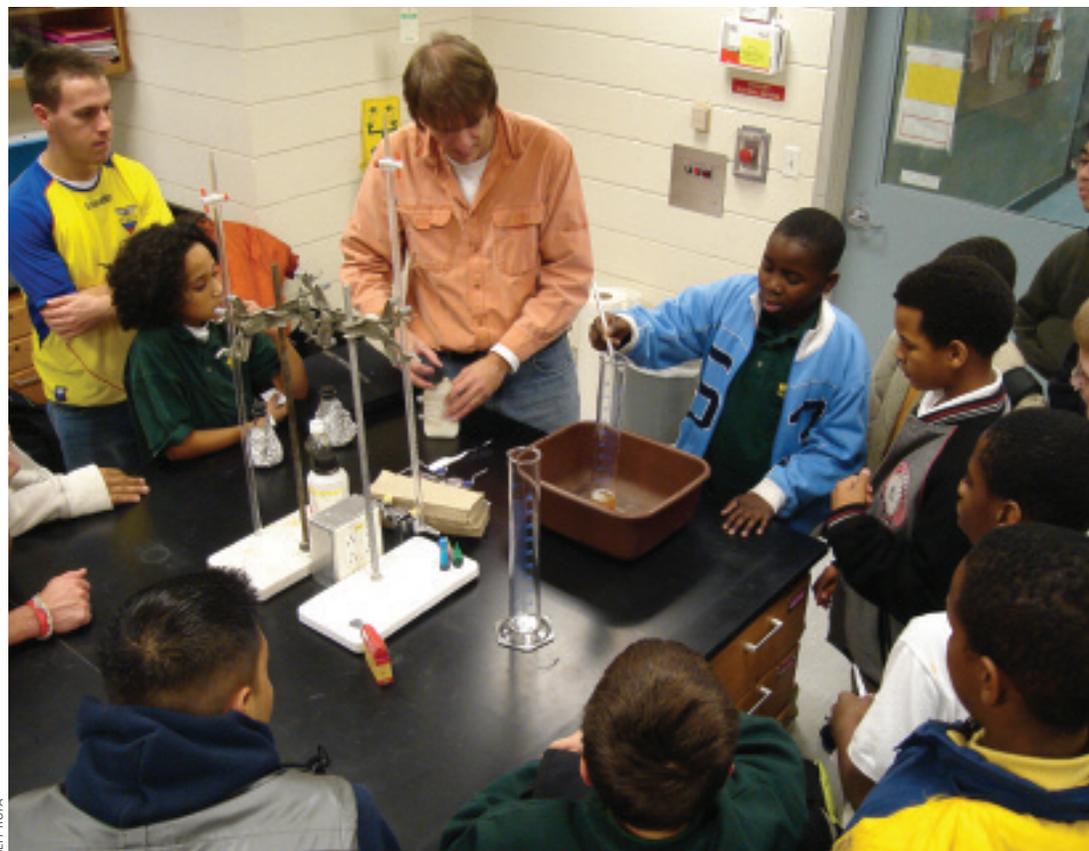
About half of all his students have gone on to medical school or a graduate program in the sciences.

Recruiting Chemists

Zimmer says that students often don't pursue chemistry because they think it will be boring or won't lead to tangible careers, as opposed to fields like nursing or engineering. But chemistry, he counters, offers plenty of job opportunities.

"One of the big challenges for [scientists] is to go out to middle schools

story continues on page 8



JEFF RUTA

Zimmer travels to middle schools and high schools to show students that chemistry can be exciting and fun.

FIND MORE @

Check out Marc Zimmer's article about the GFP Nobel Prize at <http://www.nigms.nih.gov/findings>

