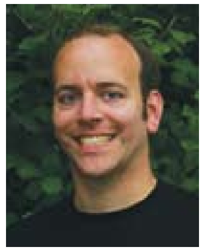
Biology by the Numbers

BY MICHAEL J. SOBIECH

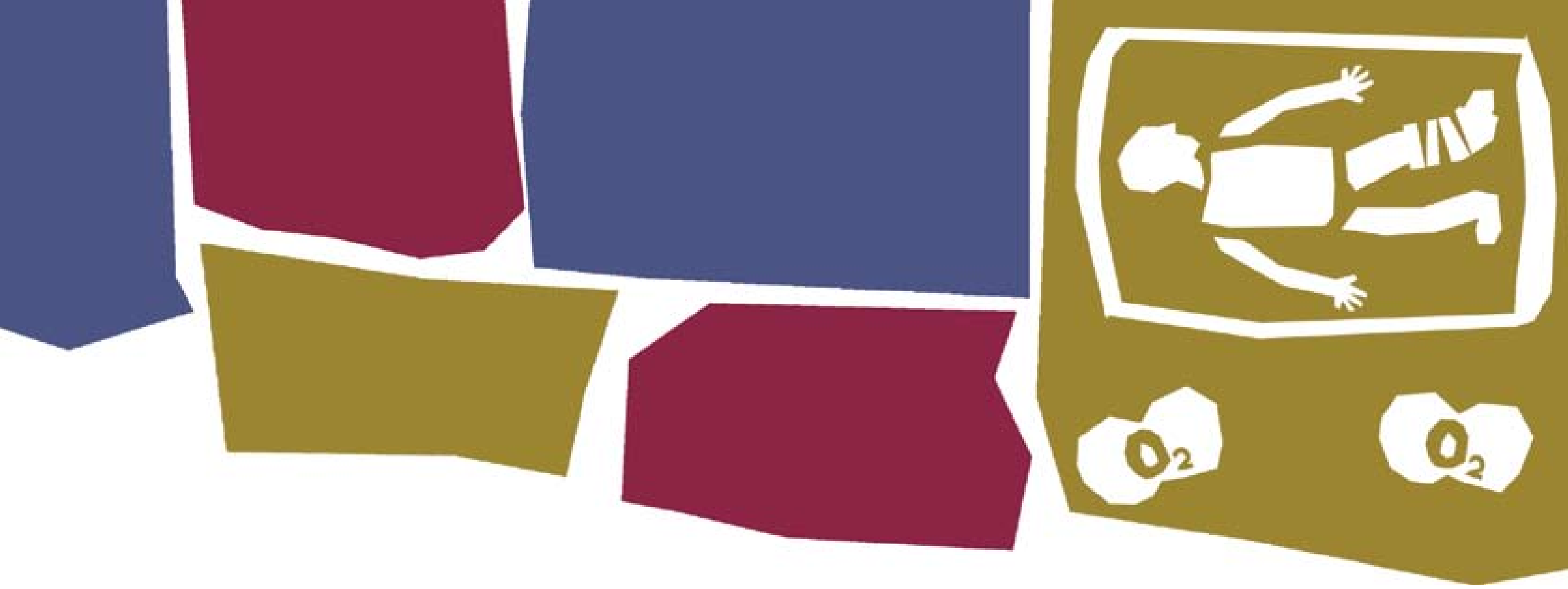


Richard Schugart

WHEN A YOUNG RICHARD SCHUGART ASKED HIS MOTHER TO DRAW HIM SOMETHING, SHE SKETCHED GEOMETRIC FIGURES. "MY MOM, A HIGH SCHOOL MATH TEACHER, WASN'T GREAT AT DOING CREATIVE ART OR DRAWING PICTURES," HE SAYS. "BUT I WAS THE ONLY KID IN KINDERGARTEN THAT KNEW WHAT A TRAPEZOID WAS — I DID, HOWEVER, CALL IT A 'CRAPEZOID.'" SCHUGART'S EARLY, AND NATURAL, LOVE FOR MATH EVENTUALLY LEAD HIM NOT TO ART, BUT TO BIOLOGY, AND CUTTING-EDGE RESEARCH ON APPLYING MATH TO BIOLOGY FOR THE POSSIBLE HEALING OF THOUSANDS.

Schugart, an assistant professor in WKU's mathematics and computer science department, always knew he wanted to study math, "But the question I faced was — What do I do with math? Go into business? Be a math teacher?" Initially, he decided he would follow in his mother and father's footsteps (his father had been a high school math teacher but changed to teaching computer science at a two-year college). "In undergrad at the State University of New York (Genesco) I started off in secondary education with a focus on math and physics. But physics showed me that I was really more interested in applied math."

When he chose to go on to graduate



school, he almost pursued physics as his field: “But I decided that I was more interested in the mathematics behind the physics than physics itself.”

Schugart’s desire to study applied mathematics led him from New York to North Carolina and North Carolina State University. “Along with all the connections they have to Duke, UNC, and various industries in Research Triangle Park, NC State has a strong applied math program; the area is a researcher’s paradise.” Like many Ph.D. students, he was not entirely sure what he specifically wanted to focus on: “But there was so much there that I knew I could figure it out.”

In determining his focus as a scholar, Schugart came across a new, and unexpected, interest: biology. “When I was in high school I hated biology. People in math often hate biology because they look at it — wrongly — as just a bunch of memorization. But when I saw more mathematical applications, I developed an interest.”

His advisor Mansoor Haider, a scholar of applied mathematics, was also interested in biology. “Mansoor collaborated with the orthopedic lab at Duke University Medical Center, where he researched properties of cartilage using mathematics.” And through his advisor’s work, Schugart found his own. “For my dissertation, I developed a computer algorithm for the kinds of problems that typically arise in soft-tissue mechanics, and I designed mathematical equations to use in studying the material properties of cartilage.”

Following his time at NC State, Schugart accepted a post-doctoral fellowship sponsored by the National Science Foundation (NSF). “The NSF funds six to seven mathematical institutes, such as the Institute for Advanced Study at Princeton. In 2001-2002, they started the Mathematical Biosciences Institute (MBI) at The Ohio State University; MBI focused on mathematical applications to biology.” Schugart, who began his three-year post-doc fellowship in 2005, was a member of one of MBI’s first cohorts.

During his time at MBI, Schugart was able to collaborate not only with his fellow post-docs but also with the hundreds of mathematical and biological scientists who visit the institute, along with OSU’s noteworthy faculty.

In bringing together math and biology, Dr. Schugart has chosen to focus on a common, complex, and chronic illness: skin wounds, such as bedsores, post-operation surgical wounds, and diabetic ulcers that refuse to heal quickly, if at all.

And what does a mathematician do with a biological problem? “We formulate a set of equations that reasonably capture the wound-healing process. Of course, that’s a very complicated process. So one of the things we do in crafting a mathematical model is make decisions about what to include and not include. And to be candid, this is an art.”

Schugart continued, “Understandably, some biologists want everything in there, but if you do that, if you include an equation for all the hundreds of proteins and cells and their interactions, you won’t be able to do anything with the math. However, if you work with just one or two equations, the math will work well, but it often won’t capture the biology. The art is determining what’s essential to include and not include in the mathematical equations. What we’re doing right now is breaking down the wound-healing process, and then working on equations for different stages or processes. Ideally, we will have equations for each stage and then combine all those into one comprehensive model, but that’s still down the road.”

Currently, Schugart and others are working on a mathematical/biological approach to try and promote blood vessel formation in a wound. "When there's a wound, the blood vessels get cut. When this happens, oxygen and other nutrients are not being delivered to the wound region. The cells need the oxygen and nutrients in order for proper healing to take place. I am looking at how we might get oxygen to the wounded area in order to help it heal."

Schugart explained, "There are different ways of getting oxygen to a wound, but I am focused on using hyperbaric oxygen. This is when you put someone in a chamber and give the person 100% oxygen at two to three times normal pressure. The person breathes in an increased level of oxygen, which the lungs process into a higher concentration of oxygen in the bloodstream. The extra oxygen will, we hope, improve blood vessel formation, which in turn, will aid in the wound healing process."

Along with the director of MBI and other researchers, Schugart has done the first step: formulate the equations and validate the mathematical model with computer simulations. Now they are using this model to explore the use of hyperbaric oxygen in wound treatment.

"We hope to accomplish at least two objectives with our mathematical model. First, the math will give us new insight into how things work — it will provide a different way of looking at a biological problem. And second, we can use that knowledge to describe potential treatments."

And the research community is paying attention. With Schugart as lead author, he and co-researchers recently (2008) published "Wound angiogenesis as a function of tissue oxygen tension: a mathematical model" in the prestigious journal, PNAS (Proceedings of the National Academy of the Sciences).

As with his love for math, there is a personal connection for Schugart and biology: "My dad has diabetes and diabetic ulcers caused by neuropathy." As the research continues to prove beneficial, the possible positive impact is immense — and not just for Schugart's father. "Billions are spent in the USA alone each year on treating wounds," he states. "And millions are dealing with this."

If wound healing is complex, so is the math that attempts to capture it. But the hope remains that part of the cure for humanity's wounds lies not only in biology but also in math. ■

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