By Sarah Webb

Big ideas on a small scale

Even when Aaron Wheeler is approached with a seemingly outlandish research idea, the one word that isn't in the analytical chemist's vocabulary is "no." He might be skeptical, says Mais Jebrail, one of Wheeler's Ph.D. students at the University of Toronto, but he'll say, "Try it out and convince me."

Such openness to new ideas has allowed Wheeler to work on a range of real world problems and scientific questions. Last year he and his colleagues found a new way to measure hormone levels in blood and breast tissue. Because the technique requires a tiny fraction of the sample typically needed for these measurements, his work could eventually help doctors diagnose cancers and monitor treatments that avoid the pain and invasiveness of traditional biopsies.

Wheeler's laboratory focuses on microfluidics — a technique in which scientists design and build tiny chips, often made of networks of small tubes. As liquids flow through these tubes, researchers can separate and analyze the chemical contents of microscopic liquid droplets.

Wheeler wants to harness this knowledge in creative ways, both to speed medical research and to better understand the natural world. In addition to measuring cancer hormones, he and his colleagues have built microscopic tunnels for tiny worms (*C. elegans*) to see if the worms can learn — a miniature version of the classic psychology experiments in which rats make their way through mazes.

The 1997 Furman graduate's interest in the connection between basic scientific research and medical applications dates to his undergraduate days. Like many chemistry majors, he went back and forth between attending medical school and pursuing a Ph.D. But during his senior year, an analytical chemistry course with John Wheeler (no relation) helped him decide on his career path.

"Not only was [Aaron] a top-notch student," John says, "he tended to stick around after class and ask questions."

Professor Wheeler made a point of assigning his students outside reading about practical applications, particularly medical and environmental research. Says Aaron, "I was just blown away that there was this field in which you could focus on and be an expert in instrumentation, electronics, optics and computer programming, but work toward biological or life-science applications." He was hooked.

After graduation he moved on to a Ph.D. program at Stanford University and plunged into the emerging field of microfluidics, learning how to design chips and using them to analyze the chemical contents of a single cell. He rapidly became enamored with the clarity of designing a microfluidic chip.

"It is so visual — just a pen and a piece of paper are all that it takes" to illustrate a possible solution to a problem, Wheeler says. But the work can be challenging. Turning the vision into reality requires troubleshooting such miniature plumbing problems as dust, bubbles and fluids flowing in unexpected ways.

"He brought this passion for trying to get something to work and the ability to persevere in the face of great difficulty," says Richard Zare, Wheeler's advisor at Stanford. "I could tell that he was going to become a great researcher."

In 2003 Wheeler moved to chemist Robin Garrell's laboratory at UCLA for further postdoctoral training. There he was able to collaborate closely with researchers in other disciplines, including mechanical engineer Chang-Jin Kim and biochemist Joseph Loo. When he was looking for teaching jobs, Wheeler picked the University of Toronto because its research environment would allow him to continue to work seamlessly with scientists in other fields.

In just five years, Wheeler's lab has become a melting pot of researchers from diverse locales — China, Brazil, Egypt and Serbia — who have broad scientific expertise in such areas as chemistry, materials science, engineering and medicine. Wheeler's Ph.D. student, Jebrail, describes himself as an "interdisciplinary gypsy."

Chance interactions with scientists from other disciplines and low barriers to collaboration have fueled many of Wheeler's projects. The study of worms in microfluidic mazes grew out of a conversation in an elevator with a biologist colleague, Peter Roy, who studies *C. elegans*, Wheeler says.

Through their work in microfluidics, Aaron Wheeler and his colleagues apply their research to real world problems.

Jianhua Qin, a visiting scientist from China, worked on the project, and since returning to the Dalian Institute of Chemical Physics, where she is now a professor, Qin and her colleagues have continued to work with Wheeler. Their connection came about in part because of Wheeler's knowledge of language and culture. He is conversant in Mandarin, a skill he picked up through a study abroad term in China during his sophomore year at Furman.

The idea to measure breast cancer hormones also came from outside. Noha Mousa, a Ph.D. student in clinical medicine, was studying breast cancer treatments that block estrogen. Mousa learned about digital microfluidics through her husband, Mohamed Abdelgawad, who had completed his Ph.D. in Wheeler's group.

With digital microfluidics, researchers use tiny electrical pulses to sort and analyze droplets on the surface of a chip. Mousa was convinced that the technology might allow her to measure hormone levels in breast tissue less invasively than traditional biopsies.

In early 2008 she approached Wheeler with an illustration and a research plan, and began working in his lab full time. She collaborated with Jebrail to develop a microfluidic system that successfully extracted estrogen from breast tissue and blood samples.

Traditional measurements can be painful; biopsies can require a gram of tissue. This technique requires a sample just a microliter in size — a pinprick by comparison.

Wheeler emphasizes that many great ideas in science are the result of researchers with different perspectives coming together and overcoming communication barriers. "[Science] really is a social enterprise," he says. "And that's one of the parts of this job that I love."

While Wheeler builds his reputation as an independent researcher, his influence is reaching back to the Furman classroom that once inspired him. John Wheeler continues to assign readings about the applications of analytical chemistry — including a recent paper by his former student, who says his broad general education at Furman was a critical tool in his growing scientific success.

Although technical training is important, "Being an academic scientist is not a matter of staying hunched over a bench in the dark by yourself," Aaron says. You also have to communicate concepts to a broad range of people: "You need to be able to go out and convince people that your work is important." |F|

Adapted from an article published in the February 2010 issue of The Scientist. *The author, a freelance writer based in Brooklyn, N.Y., graduated from Furman in 1996 and earned a Ph.D. in chemistry from Indiana University. Visit her blog, http://webbofscience.wordpress.com. Photo by Hill Peppard.*