

High School Teachers “Experience” Research at Cornell

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Each summer, the Cornell Center for Materials Research (CCMR) Educational Outreach Office welcomes nine high school science teachers onto the Cornell University campus as part of its “Research Experience for Teachers” (RET) program funded by the National Science Foundation.

For six of these teachers, it will be their first summer spent with CCMR and, in many cases, their first introduction to materials research. For six weeks, this small group of teachers will work as a team to learn about materials research and the equipment used, get acquainted with Cornell materials researchers, and learn how to connect current research to their classroom curriculum. This part of the RET program is called “Team-RET.”

The other three teachers are past Team-RET participants who have returned to Cornell for a second summer and are now known as “Individual-RET” participants. They will have the opportunity to work with faculty and graduate students in a materials research laboratory for eight weeks. They will become part of a research team, attending research group meetings, collecting data, and possibly even making new discoveries.

After completing the RET program, whether they establish an ongoing relationship with CCMR or not, it is our hope that teachers have a better understanding of research and materials science, as well as an initial understanding of current materials science research projects. We believe that this understanding will lead to excitement about materials research, and when RET teachers return to their classrooms in the fall, they will share this excitement and understanding with their students.

Tom Nabinger was a Team-RET participant in 2006. As an earth science and zoology teacher at Nottingham High School in Syracuse, NY, he was an unusual applicant among a pool of mostly chemistry and physics teachers. Like most high school science teachers, it was a passion for science that brought Nabinger to teaching. In June of 2006, before coming to Cornell’s campus, Nabinger expressed his excitement about the opportunities provided by the RET program, “I am just really looking forward to using some of the equipment that I’ve never gotten the experience of working with. . . . I’ve read about most of it any-

way, but I’ve never actually seen a lot of them or had a chance to work with them.”

CCMR’s facility managers make this hands-on experience, which is the heart of the Team-RET program, possible. Each week, the Team-RET teachers visit a new facility. The facility manager who hosts the teachers during that week puts forth a materials-science-style research challenge which the participants work

together to complete by week’s end.

During their week with Mick Thomas in the Microscopy Facility, teachers prepare two scanning transmission electron microscope (STEM) cross-section samples of titanium thin films on silicon and determine the effect of temperature on the interaction of the titanium with the silicon. The teachers are split into two groups and told that one group will be coerced into making a mistake that will completely alter their results. The mistake is subtle and made right before their eyes, yet the experimental results are plausible enough that one would not suspect that an error had been made. The challenge for the teachers is to identify the mistake.

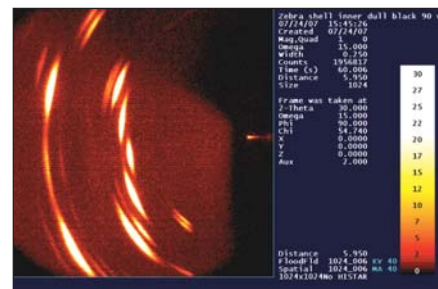
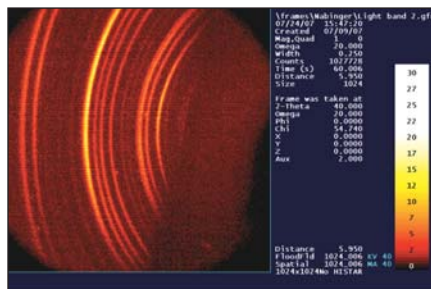
As Thomas explains, teachers soon learn an important lesson about the research process, “When teaching about research, it is easy to set up contrived experiments that are likely to succeed, or to set up experiments where the causes of failure are clear. However since neither situation really reflects what happens in the lab, the real challenge is to create an experiment that appears to succeed but actually fails due to a subtle error. To really understand the research process, it is important to realize how easy it is to make these subtle

errors in experiments and to understand the effects they can have on the outcome.”

Thomas and the other facility managers are not just experts on how the equipment works; they are experts in a very important part of the research process: using equipment and techniques to help answer research questions. Facility managers have a lot of experience



(From left): Lara Estroff, a professor in materials research and engineering at Cornell University, and Maura Weathers, a senior research associate at the Cornell Center for Materials Research and manager of the X-Ray Diffraction Facility, look on as high school teacher Tom Nabinger uses an electron microscope to view surface images of a zebra muscle shell.



Images from the general area detector diffraction system obtained by Tom Nabinger which show evidence of the regular crystal orientation found in the outer shell of a zebra muscle (left) and the irregular crystal orientation found within the inner shell (right).

Team-RET participants, 2006 (back row, left to right): Jordan Pekor, Walter Peck, and Tom Nabinger; (front row, left to right): Myriam Ibarra, Joan Erickson, and Frank LaGatta.



Ibarra (right) works with a Nottingham High School student, Matthew Fisher, in Nabinger's classroom, on a diffraction experiment during an afterschool program developed as a result of participation in the RET program.



Microscopy Facility Manager, Mick Thomas.

agers, would be essential to his success as an Individual-RET researcher. In fact, Maura Weathers, manager of the X-Ray Diffraction Facility, would become a second mentor to Nabinger as he worked to understand the shell's chemical structure and crystal orientation. In his final presentation, Nabinger used images he acquired using the general area detector diffraction system equipment in Weather's facility in order to explain his findings about the crystal orientation within the zebra muscle shell.

Along with their research experience, each RET participant is required to write a new lesson plan that incorporates an aspect of what they learned during their time at Cornell. The lesson plans help teachers make the connection between their RET summer activities and their role as a teacher. Nabinger designed an experiment that asks students to differentiate between the different classes within the phylum Mollusca.

In addition to taking home a new lesson plan, teachers also have access to the CCMR Educational Outreach Office's Lending Library of Experiments, a teacher's treasure trove of materials, activities, and experiments designed to help teach science and engineering topics. The relationships they have formed with faculty, graduate students, facility managers, and staff are also a valuable resource to RET participants. Program alumni frequently bring groups of students to campus during the school year to tour the CCMR's facilities.

Other teachers partner with CCMR more closely. Myriam Ibarra, a colleague of Nabinger at Nottingham and a RET alumnus herself with a doctorate degree in biology helped establish an afterschool science club. The club is hosted by the CCMR and Ibarra once a month in Nabinger's classroom. Programs like this allow students to have direct interaction with faculty and graduate students while participating in a hands-on activity related to materials research.

As many scientists and engineers know, one excited teacher, and even one moment of inspiration, can be enough to motivate a student to pursue a career in science. At the very least, teachers who are excited about materials research are more likely to increase the public's awareness of materials science—an important goal in its own right.

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working with researchers to make equipment, such as the TEM, work for them, and are there to help when things go wrong. Simulating this experience for teachers can be eye-opening, even for those teachers who have read about and have some understanding of the equipment. Like the students in their own high school classrooms, experiencing the research process hands-on is the best way to learn about it.

Teachers have also reported that their understanding of research in general is transformed by this experience. They no longer see research as a step-by-step set of tasks with a clear beginning and end as it is described in many high school textbooks. It is an ever-evolving process, with a lot of and trial and error, and inevitably more questions than answers.

Teachers who return for the Individual-RET program are those who are interested in pursuing a question or topic with the help of an established research team led by a Cornell faculty member.

After completing Team-RET, Nabinger

wanted to pursue a materials research project related to the zoology and earth science topics he teaches at Nottingham High School. Nabinger also explained that he wanted to "acquire a greater empathy for [his] students" by taking on the role of student himself and trying to learn something completely new. Lara Estroff, a professor from the Department of Materials Science and Engineering at Cornell, had the perfect project for Nabinger, and volunteered to host him for the summer of 2007. As a result, Nabinger had the opportunity to spend the summer researching the physical and chemical properties of the zebra muscle's shell, a topic which relates directly to both zoology (shell morphology and structure) and earth science (mineral structures and biological uses of minerals) with the ultimate objective of using this understanding in the design of new materials that mimic the unique mechanical properties of this shell material.

Nabinger quickly realized that his Team-RET experience, and everything he had learned from the CCMR's facility man-