High School Chemistry Class visits CHESS and Both Learn

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Over the course of two full days in March nearly 100 Ithaca High School sophomores and juniors trekked to and across the Cornell campus to learn about chemistry in action at the Johnson Art Museum, the Cornell Ceramics Studio and CHESS, the Cornell High Energy Synchrotron Source. This tour was part of a program designed by Kate Gefell, their enthusiastic chemistry teacher, who wanted students to see chemistry as something more than just a textbook exercise.

"I know all of you want to become scientists when you grow up" was the greeting the first group of twenty-five at CHESS heard from Ernest Fontes, assistant director of the facility. This ice breaker evokes chuckles, laughter and sometimes snarls from high school students. These responses hint at how hard it is for high school teachers to teach, motivate and convey an appreciation for science to hundreds of teenaged students. Gefell is up to that challenge, though, and the trip to Cornell is an opportunity for local scientists to build that appreciation through direct experiences.

At the Johnson Museum students learned how infrared reflectography helps art historians authenticate and examine buried features in art without altering or endangering the pieces. A hands-on activity at the Ceramics studio introduced the chemistry of glazes. Students were able to design their own sample tiles to observe how the glazes changed composition and color during the firing process.

At CHESS, students first heard a general introduction by Professor Joel Brock (Applied and Engineering Physics) about particle accelerators and x-ray production, then about the wide variety of science done with x-rays. The group of twenty-five was split into smaller sections, the first led on a tour while the second proceeded to a hands-on activity with x-ray fluorescence. On the tour, Richard Gillilan, a staff scientist with the MacCHESS group (who support macromolecular crystallography at CHESS) started with small protein crystals the students viewed using a binocular optical microscope. He then described how scientist carefully mount the soft crystals, freeze them with liquid nitrogen, and then collect x-ray diffraction photographs.

Shuttling students between tourist sites, staff scientists Arthur Woll and Darren Dale served as tour guides and answered occasional questions about radiation warning signs, high voltage, and other dangerous situations that seemed to preoccupy some of the visitors.

At a second stop on the tour, sitting in front of a large computer display, MacCHESS scientist Marian Szebenyi described how spotted x-ray diffraction photographs can be digested by computers to create three-dimensional models of complicated protein molecules. Students were eager to put on a pair of special oversized eyeglasses that let them see a true three-dimensional model of a molecule rotating on the computer screen. Invariably a student would ask about the cost of the eyeglasses, hinting at their unspoken

hope that they could own a pair for themselves. Comments like “would be a cool video game” came up naturally from each of the visiting groups.

Alternating with the tour was a hands-on activity using x-ray fluorescence (XRF) analysis. Staff scientist Peter Revesz and outreach consultant John Chiment helped students record XRF spectra from historical stone artifacts. XRF is the light, or glow, given off by a specimen when it is hit by high-energy x-ray beams. The students had a variety of flint, chert and arrowhead specimens to choose from. Using a fixed-tube laboratory source, they put their samples into the x-ray beam and recorded spectra they could match to known samples. Students used sunlight streaming through the G-line windows as a light-box to compare their paper prints to standards. When a match was made, the geographic origin of the stone could be determined.

Chiment, a paleontologist by training, described how tracing geographic origins revealed subtle information about trade routes and travel of settlers in the early history of the United States. Combined with the lessons they learned at the Johnson Museum about chemical analysis and art, this XRF lab reinforced the notion that the tools of chemists, physicists, and even large particle accelerators can play a role in the humanities and social sciences.

For teacher Gefell, the visit to Cornell was part of a larger program to show students how chemistry plays out in the real world. Gefell’s enthusiasm and drive was exactly what a local non-profit organization, called the Ithaca Public Education Initiative (IPEI), sought when they offered monetary grants to teachers who sought to enhance public school education. With a successful application, Gefell had sufficient funds to bring the classes of students to Cornell for the day. Over the course of the year, Gefell also brought a number of demonstrations in to the classroom. One of the more memorable was hosting a local blacksmith, who thrilled the class with open flames and had each student work copper stock into a teacup. Teachers and students outside the chemistry class also remember the event because the loud and enthusiastic hammering traveled freely through school walls and up and down the corridors!

The most difficult part of planning outreach activities is to impact as many students as possible and make their visit a rewarding and memorable experience. From their written feedback, it was clear that most students felt an outing away from school was a lot of fun and appreciated the change of pace. Several were disappointed because they expected an outing would exempt them from having to listen to lectures and/or presentations. Also obvious was that, being an outing, the students spent a good amount of time walking across campus and standing during museum viewings and CHESS tours. This worked fine in the morning, but the groups that returned from lunch made it obvious that they needed some “down time” before resuming afternoon activities. Unfortunately, we hadn’t planned any rest periods. Combined with a rather fast pace for the CHESS tour and XRF activity, the feedback from the afternoon sections had predictably less enthusiasm in general.

Overall the positives weighed favorably against the negatives. Having a variety of activities meant that almost all the students were engaged by and enjoyed at least one. Some of the students' comments hinted at the subtleties of science: "But I figure if they can cure one virus [rhinovirus] it is just a springboard into curing many others…" Others showed a hint of inspiration: "Working as a physicist now seems like a potential future to me", and this from a female student. In addition to the feedback students provided, the words they used revealed that the outing did "rub off". In their own words their laboratory reports did show good use of scientific vocabulary: spectra, modeling of proteins, amino acid, protein structure, process the data, fluorescence, sub-atomic particles, archeology, earth science, and different categories of physicist.

Another lesson for the light source scientists is that we cannot hide our true culture or reputed style of business. It was amusing to have one of our scientists referred to as "the one with the crazy hair." Commenting on their visual impressions of the lab, one student added "…I was surprised at how old the G-line looked, even though it was completed in 2003. It had that 1980's giant computers look to it, and, in fact, the entire facility had that feel, since there were spare computers, monitors, and other computing paraphernalia all over every surface…" And with reference to connecting science with a contemporary television show, one student added "I would love to learn more about using this sort of process [XRF] to figure out other sorts of things, like solving crimes as shown on CSI."

CHESS staff scientist Peter Revesz helps Ithaca High School students mount specimens in the x-ray fluorescence apparatus.

MacCHESS staff scientist Richard Gillilan shows students how x-ray diffraction data is collected from small protein crystals.

While wearing special eyeglasses, students see three-dimensional models of protein molecules on the computer screen, demonstrated by MacCHESS staff scientist Marian Szebenyi.

Using sunlight shining through an outside window, a student tries to overlay and match her x-ray fluorescence spectrum to those from known samples.