Editorials

Mentor's Commentary on Xiaoyu Li's Article: "*Dopamine Regulation of Cone-Cone Gap Junctions in Ground Squirrel Retina*"

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The most remarkable thing about Xiaoyu Li's project on the modulation of cone photoreceptor coupling is that it worked! This is not the typical outcome for projects in my lab, which are performed by dedicated post-docs and graduate students, and which are generally more open-ended. I thought then that this would be a good opportunity to reflect on the ingredients that went into making this a successful high school project. I hope that this reflection will be helpful to high schools and perhaps early college students who are considering working in a lab in a university or medical school environment.

Xiaoyu's residential high school, the Illinois Math and Science Academy, sponsors a program, SIR, in which Junior and Senior students have the option of working in a university lab one day a week throughout the academic year. Thirty days seems like a lot of time to spend in a lab, but it leaves no room for the expected false leads and dead ends associated with original inquiry. Xiaoyu indicated her interest in basic research on early visual function, and I presented her with several project options. It is rare for even graduate students to conceive of their own projects. Projects had to meet the following criteria: They had to address an unsolved question that was important for the lab, they had to involve concepts and techniques that were within the reach of an advanced high school student, they had to be feasible for the short period of time involved but not guaranteed to work, and had to involve a series of intermediate steps or optimizations that could provide yes/no answers along the way. Like everyone else in the lab, the student must work independently.

Xiaoyu's project on the modulation of cone-cone coupling admirably fit these criteria. Mammalian cones are coupled by gap junction channels, but whether the channels are modulated by light is controversial. In the lab, we can use patch clamp recording to measure the electrical current flow through the gap junctions between cones, but such paired recordings are a sure fail for a high school student with limited time. Instead, Xiaoyu used an antibody raised by a colleague that recognizes, in fixed tissue, whether gap junction channels are phosphorylated. Phosphorylation is associated with the open state of the channel. Antibody labeling, both conceptually and procedurally, is an appropriate procedure for a high school student. Labeling was analyzed by imaging the isolated retina with a laser scanning confocal microscope, and then processing those images with a software program called Metamorph. Xiaoyu succeeded in mastering both tasks, which are quite demanding. Finally, there were a number of optimizations involved before the final assay could be performed. The antibody against phosphorylated Cx36 only works in a very unusual fixative, carbodiimide, and we were not sure whether our other antibody markers would work under the same conditions. We also did not know whether the cone-cone gap junctions would be better viewed in tangential or cross sections, and we did not know how long a drug incubation or treatment to use to modulate the gap junctions. Achieving these small steps was critical to the ultimate success of the experiment, and critical for Xiaoyu in that it gave her a sense of progress.

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A Teacher's Personal Philosophy on Science Education ("*Correlation Between Nitrogen and Oxygen Content in Planetary Nebulae Morphology*")

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I believe that I was meant to be a science teacher so that I can inspire people to solve the problems that exist on our Earth. The students in our classrooms today will be the ones responsible to engineer, invent and collaborate to ensure the success of all species. Every student is expected to rise to the challenge of learning science well enough to be able to create their own trail to the development of those solutions. I believe that there is no excuse for why a child should fail and that it is my job to do everything in my power to ensure their success. The enthusiasm with which I live and work is meant to "rub off" on the students to help bolster their self efficacy about their abilities in the classroom. With the support of someone who believes in them, the understanding that they can succeed and the enthusiasm to seek out opportunities, a student grows into the person that all children have the potential to become.

Underrepresented Groups in Research and the Value of Internships from Small Business Grants *("The Synthesis and Size Reduction of Dispersed Aggregates of Molybdenum Oxide Nanoparticles for use in Long Chain Hydrocarbon Cracking")* (article submitted for future issue)

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Natalia Anderton and Brielle Woolsey were students of mine in chemistry and AP Chemistry at Springville High School in Springville, Utah. Springville High School has a student population of 1251 made up of mostly middle class white students with a minority population of 14%. At the end or their junior year, the students were offered a Research Assistantship Supplement for High School Students as part of a Small Business Technology Transfer Research Phase II Grant from the National Science Foundation to Cosmas, Inc. I was offered a Research Experiences for Teachers Award as part of the same grant.

NSF strongly encourages the participation of underrepresented groups in science, technology, engineering, and mathematics. The Research Assistantship Supplements for High School Students support active research participation by high schools students in projects funded by the NSF SBIR/STTR Programs (programs for small business innovation research/small business technology transfer). RAHSS projects involve students in meaningful ways in ongoing advanced applied research projects that offer societal benefits. This opportunity helps increase participation of women and under-represented minority students in academic and small business research to foster interest in pursuing science, technology, and engineering studies at the college level.

Cosmas, Inc is a startup nanotechnology company created by several Brigham Young University chemistry professors that I have collaborated with previously on other projects. Although these research opportunities are available as part of these NSF grants, few small businesses participate in offering them to high school students and teachers.

The students and myself knew absolutely nothing about the creation and analysis of nanoparticles. Cosmas explained the principles and concepts to us and then I was able as their teacher to communicate in ways that they could understand. They were required to attend a Research Collaboration meeting each Friday for one

year, where all of the researchers would report on their progress for the week and seek suggestions for further work. The students were able to participate in the discussions about very specific and complex research with progressing understanding. They also had time each week to explain their own work and seek suggestions for continued progress.

The students found that research is very difficult and many failures precede success. They learned that failures could often provide more information than successes. The students were tasked with a project that Cosmas needed researched but as a small company did not have the resources to address. This project was the production and analysis of molydenum sulfide nano particles for use as a catalyst in crude oil cracking processes. During their work, the students were able to create the molydenum oxide precursor but could never find a method to replace the oxide with sulfide. The various methods tried could be considered failures yet the students and Cosmas now know that those methods will not yield success.

The students used several research instruments worth hundreds of thousands of dollars that would never be available to high school students. They became so adept with the nanoparticle mill and particle size analyzer that Cosmas requested that they wrote the standard operating procedures for all company employees before their assistantship was completed.

When the students had created some product, it was sent to a graduate student in the chemistry department at Brigham Young University for analysis with x-ray diffraction. During a parent-teacher conference that year, the father of one of my other students realized that his graduate student was working with my high school students on his x-ray diffraction instrument. He offered to spend time personally with Natalia and Brielle in allowing them to operate the instrument themselves and explaining how the data is analyzed.

These opportunities for research provided a rare experience for my students. Teachers and students should seek to encourage other small business grant seekers in their area to do the same.

Teacher's Commentary on Lei Zhang's article: "*Identification of AKAP150 in Presynaptic Axon Terminals of the Basolateral Amygdala*"

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The Magnet Program at Wheeler High School offers a unique Internship/Research experience for all Seniors. The students select a local business or university to be their place of Internship for a twelve week period. While interning, the students are required to conduct a formal research project that includes at least three sub-problems. The final product from the internship is a Research Portfolio that is similar to a mini-doctoral dissertation.

Lei Zhang is an exceptional student who chose to do her Internship at the Yerkes Primate Center at Emory University. She worked with Dr. Christopher Muly. Dr. Muly's lab studies the organization of the proteins involved in neurotransmission in the brain and how experience, and in particular stress, can alter this organization. Lei spent the summer examining the localization of a particular protein, the A-kinase anchoring protein-150 (AKAP-150), in the amygdala of the rat. AKAP-150 is critical for synaptic plasticity and learning in a brain region involved in anxiety and stress responses.

Lei's experience in Dr. Muly's lab provided her a unique opportunity to do doctoral level research at one of the nation's top universities. Additionally, Lei was able to get first-hand experience in the field of medical research. Lei continues to do research in Dr. Muly's lab, as well as spending some of her Internship time at the Center for Disease Control (CDC) in Atlanta.

The Journal of Experimental Secondary Science

Does High School Science Teach Kids to be Scientists?

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Based upon years of Research and Development work before I began teaching I would say emphatically that most high school science courses do not teach students how to be researchers. Put differently, mostly we are ill equipped, underfunded, and expected to turn out students that meet very defined standards that were established by well meaning scientists that wanted to address the public demand for quality public education in the sciences.

There are rare occasions in my public school instruction when I am able to direct a student to an opportunity to work in a research lab. The vast majority of our students will never have the real experience of designing an experiment that will elucidate the inner workings of a particular system. Mostly we have no avenue to allow students to perform open-ended research on problems that have yet to be solved even though we know that is the essence of "doing" science.

At public schools we are under constant pressure to "perform" by coaching students to do well on standardized tests that have nothing to do with the way in which science is actually done. Unlike the charter schools or private schools, we are locked into a diabolically circular process where we are constantly proving the "value" of our school though providing no proof that we are actually mentoring students toward becoming "scientists." For students to become scientists they would have to be engaged in science and our standardized system of tests do not evaluate their ability in this respect. It evaluates their ability to remember facts.

Now that we have been administering standardized test for 20 years we can easily see that we are not preparing our students better for careers in science. In fact we can see that the only certain outcome is that we have systematically deprived our students of nearly a year of cumulative instructional time in favor of measuring students' "progress" more often than farmers weigh their cattle.

If we are to find a way to reach out to the masses of students in public schools that crave science because it allows us to solve complex problems, we must find a way to educate our legislators, the public, the corporate world, and the educational establishment so that they quit demanding that we create science "widgets" that really don't know how to do science at all, but are capable of passing the tests "we" created to measure their "success" at the lowest possible cost per exam. These "widgets" are our students and we owe them a better opportunity to learn how they can become inquisitive scientific thinkers and doers that can contribute to the betterment of our society through their research.

In a time when there is an endless supply of "information" available at the click of a "mouse," we need to find ways to have our students spend more time processing information and creating new knowledge. This may start by "allowing" our students to use their cellular devices to access information on the web to answer questions posed in class instead of banishing them for using their devices inappropriately.