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2013-2014 Newsletter

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STEM ED

FROM THE DIRECTOR

MORTON STERNHEIM

Broader Impacts and Partnerships

The National Science Foundation requires research proposals to include a “broader impact” on areas such as education, the participation of underrepresented groups, or increased public scientific literacy. Many other federal funding agencies have similar requirements. STEM Ed has participated in sessions organized by the UMass Office of Research Administration to suggest broader impact options to faculty members. We have also worked with many researchers in recent years to create STEM outreach components for their proposals; these generally have been well reviewed, whether or not the proposals were funded. The proposals have led to some rewarding partnerships.

Our oldest current partnership with a research program, the Center for Hierarchical Manufacturing, dates back almost a decade. The CHM is a large, NSF funded nanotechnology research center. Co-PI Mark Tuominen (Physics) leads an ambitious education agenda for the center. It includes new undergraduate and graduate courses, the development of courses for technicians in cooperation with Springfield Technical Community College, and the creation of multimedia web materials. STEM Ed has worked with Mark to create summer institutes and other workshops for secondary STEM teachers. Nanoscale science and engineering is a new field with limited curricular resources, so we have developed a variety of materials that can be adapted to varied classroom settings (see www.umassk12.net/nano). This development has been done with the aid of retired teachers Rob Snyder and Terry Dun, middle school teacher Jennifer Welborn, and engineering professor Jonathan Rothstein. Our weeklong summer institutes are oversubscribed, with teachers coming from all over the country even though we can only provide a modest stipend and do not cover travel costs. Presentations at the national meetings of the National Association of Science Teachers and at other venues are well received.

CAREER grants from NSF are five year awards that support the development of junior faculty. They explicitly require the integration of research and education. One recipient is UMass physicist Benjamin Davidovitch, who conducts theoretical research on the patterns that arise when conflicting forces act on a material. We have helped him to organize a two day teacher summer workshop and a half day Saturday program; science teachers Jennifer Welborn (Amherst Regional) and Wayne Kermenski (Mohawk Regional) and physics professor Narayanan Menon helped to develop materials (see www.umassk12.net/patterns). Another CAREER recipient is geologist Linda Elkins-Tanton, formerly at MIT and now at the Carnegie Institute in Washington. She offered two summer programs here at UMass with our logistical assistance.

Two other recent collaborations include arranging an opportunity for Alice Cheung (Biochemistry and Molecular Biology) to share her research on pollen with teachers, and providing support for a computer teacher program organized by Richard Adrion (Computer science).

We look forward to forging more partnerships aimed at improving STEM education at all levels.

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New Patterns Workshop Launched in Summer 2013
By Jennifer Welborn and Wayne Kermenski

Have you ever noticed the wrinkling pattern created when a shower curtain is opened? Neither had we until we met Dr. Benjamin Davidovitch, UMASS physics professor. Professor Davidovitch specializes in wrinkles and studies their application in materials science, most notably the determination of the thickness of nano-scale thin films. Nano-scale films wrinkle when forces are applied and the wrinkling pattern can be quantified! Wayne Kermenski, a high school science teacher from Vermont and myself, a science teacher at Amherst Regional Middle School, were invited to work with Professor Davidovitch as part of a career grant he was writing. The grant required an outreach component which was to include both teacher training and a K-12 curricular component. Professor Mort Sternheim contacted Wayne and me to see if we were interested in developing curricula and helping to present a workshop to teachers on the subject of wrinkling. WRINKLING??? I have to say that Wayne and I were hesitant to commit because it was a big stretch to link wrinkles to K-12 state standards. A BIG STRETCH! After many coffees and chats and meetings with Mort and Benny, however, Patterns Around Us was born. As science and math teachers, we want our students to see patterns and make meaning from them. The whole of science is about recognition of patterns, researching their cause and predicting their appearance in novel situations. In fact, the description of science and its link to pattern recognition is the keystone of state and national standards and next generation science standards.
"Science may be described as the attempt to give good accounts of the patterns in nature. The result of scientific investigation is an understanding of natural processes.... Overall, the key criterion of science is that it provides a clear, rational, and succinct account of a pattern in nature...."

The first Patterns Around Us workshop was held July 1-2, 2013. What set this workshop apart from other ones which address patterns was THE KINDS of patterns investigated by the participants: wrinkling; buckling; and branching. All three of these patterns are seen in the natural world and have applications in materials science. Participants first investigated wrinkling patterns in skin and learned about the importance of quantifying this pattern to predict and infer wrinkling patterns in other kinds of materials. Dr. Davidovitch presented his research showing wrinkling patterns which form when various materials interact. Participants moved on to an inquiry lab about the concept of buckling. Buckling has a natural interdisciplinary connection with living things. In order to survive, living things must be able to withstand live and dead loads without buckling. An additional activity was the investigation of wrinkling in peas. Participants engaged in a series of labs which served as a guided inquiry into why some pea seeds are wrinkled and others are not. This pattern was noticed first by Gregor Mendel, the father of genetics. His observations of the wrinkling pattern in pea seeds led him to develop the fundamental laws of genetics. The workshop concluded with an investigation of branching patterns in fluids and plant roots.

We will be presenting highlights of the workshop at the NSTA National Convention in Boston in April. Another Patterns Around Us two- day workshop will again be offered June 30-July 1, 2014. More information about the program is online at www.umassk12.net/patterns.

The iCons program approaches mile-stone

By Bridget MacDonald and Scott Auerbach

On January 18, 2011, iCons Program Director Scott Auerbach observed from the back of a lecture hall in UMass Amherst's Integrated Sciences Building as the first cohort of iCons scholars – known affectionately as "the guinea pigs" – brought the first iCons course to life.

"Standing in that room and listening to these students, I realized in the deepest part of my heart and mind that we were on the right track," he said. "It was better than we ever could have hoped."

What Auerbach and his team hoped for is captured in the program's mission: To produce the next generation of leaders in science and technology with the attitudes, knowledge, and skills needed to solve the inherently multi-faceted problems facing our world.

Now with the guinea pigs entering their fourth and final semester, the first full cohort of iCons scholars will soon head into the real world to realize this mission. When these students graduate in May, the program will reach an important milestone as well. From an idea proposed in 2006, iCons has evolved into a living, breathing, four-year academic program that is uprooting expectations about what undergraduates are capable of achieving.

"Standing in that room and listening to these students, I realized in the deepest part of my heart and mind that we were on the right track," he said. "It was better than we ever could have hoped."

More than just maturing, iCons is thriving. The number of applicants has grown each year, and the increasing interest has helped fulfill one of the primary goals of the program – integration between disciplines. In the first year, the applicants represented 10 majors in two colleges. This year's pool of applicants encompassed 25 majors and five colleges.

The growth is due in large part to the program's most vocal advocates: its students.

"iCons is not just a class, it's an attitude for approaching the world," explained Debbie Tschong, a junior and member of the second iCons cohort.

Embodying the philosophy that in iCons, nothing is "just a classroom exercise," Tschong and fellow students Erin Amato and LeAnn Monteverde were inspired to bring the program's team-based approach to problem solving into the real world. Last fall, the students helped organize and lead iCons case study workshops with participants in Girls Inc., a program that provides academic support and mentorship to girls from underserved communities.

The initiative has blossomed into a partnership with UMass Civic Engagement and Service Learning, which will establish two internships exclusively for iCons students to work with Girls Inc. over the summer. It's an indication of the program's level of commitment to training the next generation of science leaders, not only by raising the bar in STEM education at UMass, but by reaching out to help level the playing field so students of all backgrounds can succeed.

To learn more about the iCons program, please visit our website:
https://www.cns.umass.edu/icons-program/

STEM Ed and MassBioEd Offer new Hands on Science Workshops to Area High School Teachers on March 21st and 22nd

MassBioEd, the Pioneer Valley STEM Network and the STEM Ed Institute invites middle and high school teachers to attend two one-day biotechnology education workshops led by Don Salvatore. Participants can choose one or both workshops. Workshop topics include:

Do It Yourself Biotech Lab Kits
Because of the increasingly important role biotechnology is playing in all facets of biology, it is critical that that today's students are introduced to basic biotechnology tools. However, these tools are expensive and often schools cannot afford the consumable supplies and reagents to offer biotech labs to all students. So, why not have teachers and students make their own lab kits? The Do It Yourself (D-I-Y) approach will not only save schools thousands of dollars, but will provide teachers and students the opportunity to better understanding experimental procedures and hone basic laboratory skills. In this workshop we will demonstrate how to prepare the solutions and reagents for a basic DNA fingerprinting experiment and for a bacterial transformation experiment geared for a high school classroom laboratory. Participants will prepare a kit, for up to 30 students, for each of these labs that they can take back to their schools. In addition, participants will leave the workshop with the protocols and a comprehensive supply list including, sources, catalog numbers and ordering information, necessary to prepare all required solutions and reagents for these experiments.

Do It Yourself Biotech Equipment
Because of the increasingly important role biotechnology is playing in all facets of biology, it is critical that that today's students are introduced to basic biotechnology tools. However, these tools are expensive and often schools cannot afford this equipment, so many students never have the opportunity to do biotech labs. So, why not have the students build their own equipment? The Do It Yourself (D-I-Y) approach will not only save schools thousands of dollars, but will provide students will a better understanding of what the equipment does and will give them the confidence to build their own equipment when no commercial product is available. The homemade equipment demonstrated in this workshop will be introduced through two simple labs - a microbiology lab and a gel electrophoresis lab. In addition to using homemade equipment, we will explore how these labs can be performed using grocery-store substitutes for more expensive reagents.

Visualizing Biotechnology through Paper Activities
Given the number of important new discoveries being made every day using biotechnology tools, it is not surprising that many schools have incorporated biotech labs into their curriculum. But unlike many other sciences, biotechnology is an "invisible" science and students usually can't see what is happening; often they simply add one clear liquid to another clear liquid and hope for the correct results. This workshop demonstrates what is actually happening in the test tube. By manipulating paper cutouts of the molecules involved in each lab, students come to a better understanding of what is taking place in the experiments they are performing. The paper activities developed for this workshop were designed to support a number of commercially available classroom labs including gel electrophoresis, bacterial transformation, PCR, ELISA and SDS PAGE.

Participating teachers will receive seven Professional Development Points (PDPs) for each workshop.

Register at the MassBioEd website: https://www.massbioed.org/events/80-do-it-yourself-biotech-lab-kits-workshop-making-and-using-homemade-biotech-lab-kits.
For more information contact MassBioEd Director of Biotechnology Education, Alice Rushforth at alice.rushforth@massbio.org

About the Instructor:
Don Salvatore has been a science educator at the Museum of Science in Boston for over 30 years. He has developed a range of curricular materials and teacher training workshops in partnership with Boston University CityLab and MassBioEd to support biotech education efforts in Massachusetts high schools and at numerous regional and international conferences.

Keeping Track of our Arsenic Intake: A Possible Citizen-Science Project

By: Julian Tyson, Department of Chemistry, UMass Amherst

Background

It has been known for well over 100 years that our food, beverages and drinking water all contain low concentrations of arsenic. But it is only relatively recently that the details of possible health hazards are emerging. The large number of arsenic compounds that are found in the environment may be classified as (a) naturally occurring, (b) deliberately introduced, and (c) accidentally introduced. Biological processes in both the aquatic and terrestrial environments transform these arsenic compounds, and both the products and reactants are transported around the surface of the planet, so it is inevitable that they get into food and water. We have known since the late 1980's that the forms of arsenic that occur in fish and other seafood, in relatively high concentrations, are not harmful at all. In other foods, only four compounds are found: the two inorganic compounds, arsenite and arsenate, and two methylated derivatives of arsenate known as monomethyl and dimethyl arsenic (MMA and DMA). The trimethylated compounds are known but are not found in food and drink, and the tetramethyl compounds are the harmless ones found in fish. The inorganic compounds are considered to be non-threshold, class 1 carcinogens (i.e. they definitely cause cancer in humans, and there is no dose that does not produce a response). Less is known about the toxicity of MMA and DMA, which at the moment are considered to be of intermediate toxicity but non-cancer-causing in humans.

It is only in the last 15 years or so that any details about the nature and amounts of the different arsenic compounds in foods other than fish have been reported. Although the data is really very limited at this stage, there is convincing evidence that rice contains much higher concentrations of both inorganic arsenic and DMA than does any other foodstuff..Modeling studies of how much arsenic we ingest from our food and drink based on these rather limited data support the notion that many of us (in both the USA and Europe) are exposed to inorganic arsenic through the consumption of rice and rice products at doses that exceed what is considered acceptable. As there is no dose that does not produce an increased risk of getting cancer, what is acceptable is defined in terms of the associated risk. In the USA, relevant government agencies think that the acceptable risk threshold is one in ten thousand; in Europe, the risk threshold is one in a hundred. Scientists in the USA have also calculated the value for the dose that corresponds to the 1 in 10,000 risk to be 0.027 micrograms of arsenic per kilogram of body weight per day. This translates, for a 160-lb adult to about 2 micrograms (μg) of arsenic per day.

The November 2012 issue of *Consumer Reports* contained the results of the analysis of 65 rice and rice-based products, just under half of which were rice (both brown and white). Concentrations of (a) the total arsenic, (b) the sum of the two inorganic arsenic compounds and (c) the sum of DMA and MMA were reported for 3 or 4 lots of the same product. The highest values found (all in rice grown in the USA) were about 900, 200 and 850 micrograms per kilogram (kg) of rice, respectively. If the arsenic ingested from a typical 45-gram serving of rice is not to exceed 2 μg, the concentration of inorganic arsenic should not exceed 44 μg per kg. Of the just under 100 analyses of rice reported, only 6 values were below this threshold, and so not surprisingly, as most of us ingest arsenic from sources other than rice, *Consumer Reports* recommends that adults restrict their rice intake to 2 servings per week.

It is going to be some time (maybe quite a long time) before bags of rice come with the inorganic arsenic concentration printed on the label, and as we have very little idea of how concentrations are changing over time, I am proposing that "citizen scientists" could contribute data for such a study as well as keep an eye on how much arsenic they were eating *if* there was a way to measure the inorganic arsenic content of rice that could be carried out in the kitchen (or, for those households with school-age children, in a school lab).

Chemical Measurement.

The determination of the arsenic species in rice is within the capabilities of modern analytical chemistry. After thorough mixing of grains and grinding to a flour, most expert laboratories will prepare a solution of the arsenic-containing compounds by extraction in a sealed vessel in a scientific microwave oven followed by centrifugation. A small portion of the extract is then injected into a high performance liquid chromatography apparatus. The separated compounds are washed sequentially off the chromatography column into a plasma-source mass spectrometer acting as an element-specific detector. The detection capability of such as method is between 1 and 10 μg of arsenic per kg of rice for each of the four arsenic compounds that might be found in rice (namely, the two inorganic compounds together with MMA and DMA).

Arsenic Article Continued…..

Clearly, a different approach is needed for a method performed in the kitchen. My hypothesis is that such measurements *are* possible by suitable adaptation of the home/field test-kits designed to measure arsenic in drinking water. A number of companies make such test-kits, and most are based on the Gutzeit modification of the Marsh test. The version of this that we use in our research, made by the Hach company, requires a 50 milliliter (mL) sample volume, and can detect down to 10 µg of inorganic arsenic per liter of solution, (the current US EPA maximum limit for arsenic in drinking water.) That is, the test can detect a mass as low as 500 nanograms of arsenic.

Arsenic compounds in rice can be extracted with hot water, but working directly with grains has proved difficult, a considerable fraction of the solution (and hence the extracted arsenic) is absorbed by the partially cooked rice. However, it is not difficult to grind a known mass of rice to a flour, this may help to overcome the problem of limited transfer of arsenic compounds into the solution. The next stages of the analysis are not so easy. A considerable amount of starch is also extracted and this interferes with the reaction between the arsenic and the zinc. It does not suppress it completely, but it renders the color chart provided by the Hach Company inaccurate. I have a number of ideas for overcoming these problems, and the on-going development of the method forms the basis for projects for undergraduates, working both in the arsenic-project (See STEM Ed. Inst. Newsletter 2008) and in independent study in my group. One modification we made a few years ago replaces naked-eye detection with digital image analysis with the help of the AnalyzingDigitalImages software developed by John Pickle and used in the STEM DIGITAL program.

Citizen Scientists

I was awarded a small grant by the American Chemical Society for a pilot program providing a public lecture-demonstration on the UMass Amherst Campus in December 2011 followed by distribution of test-kits to interested members of the audience, together with instructions for how to measure the arsenic content of rice in their kitchens. Participants could work through the calculations themselves or could send back a photograph of the exposed test strips placed next to the printed color chart that was included in the package. Just over 30 volunteers were recruited of whom 5 sent back results, all of which were positive in the sense that measurable colors were obtained on the test strips. But it was clear that the procedure needed further development.

Following this program, I wrote proposals to the National Science Foundation for funds to support its further development. In addition to refining the extraction procedure, dealing with the starch interference and calibration accuracy, it is necessary to demonstrate that when the results of the analyses are compared with those of the same materials obtained by the scientific laboratory procedure described above, there are no significant differences.
Unfortunately, the relevant directorate at NSF did not find this work sufficiently compelling and two proposals were rejected. In the meantime, I have further preliminary data from participants in (a) the STEM Digital summer workshops in summer 2012 and 2013, (b) STEM Ed Saturday seminars in March 2011 and 2013, (c) a summer college experience for high school students in 2012, and (d) the participants in the course NATSCI 697J (STEM DIGITAL) for members of the Science Ed. Online Masters program. All have found that it is possible to detect arsenic in rice by a "kitchen-based" method. In addition, two groups in the arsenic project and two participants in the UMass College of Natural Sciences First-Year Research Experience during the fall semester of 2013 and a group of high-school students at Four Rivers Charter School in Greenfield are exploring how to improve the performance of the test. In particular they will look at the effects of time and temperature on the basic arsine-generation reaction.

Other Challenges

There is considerable parallel activity in the analytical chemistry research community in response to calls for the introduction of regulations on the concentrations of arsenic compounds in foods and beverages. Any arsenic-in-food regulation has to be underpinned by the availability of reliable chemical measurements. The reported capability of laboratories around the world to measure the inorganic arsenic content of rice are worrying: only about half of the participants in a recent proficiency test run by a European agency obtained what the organizers called "satisfactory" results. Results of the analyses of different lots of the same rice by one laboratory show much greater variability than would be expected if the only source of variation was the random fluctuations in the response of the instruments. My students have shown very recently that this might be due to sampling errors, as we have found that (a) concentrations of arsenic in individual grains can vary by as much as a factor of 2000, and (b) rice may contain just a few percent of "super grains," containing up to 5000 µg of arsenic per kg, compared with the more usually encountered concentrations of 10 – 100 µg of arsenic per kg of rice. This has serious implications for the procedure by which a sample is taken from a bag.

Can I help?

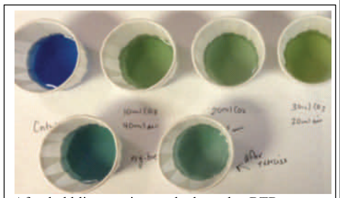
The project is at a really interesting stage, and I would be very receptive to offers of help. I have almost no financial resources (and so one way to help is to identify potential funding agencies to which I can apply). To get involved with the experiments, you need access to a kitchen or a lab with the necessary equipment to grind and "cook" rice, and you need a digital camera. You also need at least one EZ arsenic test kit from the Hach Company, which costs about $50 and provides two reaction vessels and reagents for 100 tests. To discuss participation in the project, send me an e-mail at Tyson@chem.umass.edu.

STEM-DIGITAL in a Digital Classroom

STEM-DIGITAL has been a fun and enriching program over the last 3 summers working with STEM teachers on Digital Images in Geoscience Investigations: Teaching Analysis with Light. Funded by the National Science Foundation's Innovative Technology Experiences for Students and Teachers (ITEST) program, STEM-DIGITAL showed how students can extract a wide variety of scientific information from images as they carry out experiments. Digital images are good for much more than pretty illustrations, and they are worth far more than a thousand words! They contain quantitative information about colors, brightness, sizes and directions that can be used to make all sorts of measurements: growth rates, chemical changes, shadow angles, water transparency, and much, much more. This can facilitate a wide variety of experiments, and it introduces students to skills needed for careers in the burgeoning area of digital image analysis.

One of our goals was to build a lasting legacy for the STEM-DIGITAL project, so from the start we used the summer workshops as a test bed for a future online course, including making videos of some of the presentations and projects for use in the online course. And what could be more appropriate than a digital classroom to study digital images? In fall 2013, we made the leap into the virtual online classroom, and once there we were very pleased with the great work carried out by our online cohort of science teachers.

The dynamic of an online classroom is so different from a face-to-face workshop that the transition is a bit daunting. However, with digital images being the main method of recording data, it was easy to share and compare data, and even re-measure results. For example, in one experiment we measured the carbon dioxide level in air samples by bubbling them through a BTB solution. This might be used to show the relative amounts of carbon dioxide in your breath before and after exercise. In the summer program, teachers carried out these experiments in the lab, took photos, and put the images on computers for measurement. In the online course we created a kit with the necessary chemicals, cups and air syringes, which we shipped out at the start of the semester. Just as in the summer, the teachers worked in groups to plan their experiment, then took photos that they shared online, where they measured and discussed them. It appeared to us that the online discussions were, if anything, even deeper and more detailed than the discussions we listened in on during the face-to-face workshops. That's almost inevitable because everyone has to write down their thoughts in the digital classroom.



After bubbling an air sample through a BTB solution (blue), it turns green or even yellow depending on the percentage of CO_2 present.

The analysis of the digital images was made possible by Analyzing Digital Images (ADI) software developed by John Pickle initially when he was at the Museum of Science in Boston, and further developed during the course of the STEM-DIGITAL project. For example, the software can measure RGB color levels in each of the CO_2 sample cups shown in the image, selecting a region in the cup that is unshadowed. The color change can then be measured quantitatively and compared to the color produced by samples with known percentages of CO_2. John uses ADI with his students at Concord Academy for a wide variety of experiments, and he's constantly coming up with new ways to use image analysis to enhance existing lab experiments and create new projects.

One of the most exciting parts of the STEM-DIGITAL project for us is to see the imaginative uses teachers come up with for using image analysis in their own classrooms. The 15 teachers in our pilot online offering were no exception. They developed lesson plans covering widely varying topics such as: creating topographic maps, studying the physics of light, carrying out a forensic examination of a "crime" scene, comparing Galapagos finch beaks, and analyzing stellar spectra. These are not only clever ideas, they help students carry out authentic scientific investigations.

Our plan is to continue offering the STEM-DIGITAL online course in the future. The course will keep the things that worked best this last fall, but we also plan to use the great lesson plan ideas that past participants have developed to keep the course fresh. STEM DIGITAL curriculum materials are online at www.umassk12.net/digital. ADI software is available at www.umassk12.net/adi.

"My students treat technology as an extra appendage they cannot live without. It can be challenging at times, especially with eighth graders, to consistently find engaging and inquiry-based lessons...ADI software is a very effective tool, especially when identifying the amount of color that we cannot determine by the naked eye. And it is the type of technology I can see incorporated into the science classroom on a regular basis. I like the "discovery" aspect of it as well. " 2013 SEO participant

Nanotechnology Continues to be Big

By Mort Sternheim

STEM Ed hosted its seventh nanotechnology summer institute this past July, and once again we were unable to accept all the teachers who wanted to attend. Most of our institutes are funded by the STEM education programs at NSF or NASA for three years, and by the third year we seldom have to turn anyone away. By contrast, the nanotech institute is part of the broader educational component of the large NSF-funded UMass Center for Hierarchical Manufacturing (CHM), and is funded for nine years.

Led by physicist Mark Tuominen, the CHM educational initiatives also include new undergraduate and graduate courses at UMass, multimedia modules, and materials for community college students preparing to become technicians.

2013 Participants, assisted by Jennifer Welborn, Institute Instructor

Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers (nm), where unique phenomena enable novel applications. A nanometer is one billionth of a meter, or about ten atomic diameters. Nanotechnology has applications to electronics, catalysts, water purification, solar cells, coatings, medical diagnostics and therapy, and much more. For example, Intel promises to deliver chips with 10 nm spacing by 2015, allowing it to pack huge numbers of transistors onto one tiny chip.

Because of the great interest in the field, we attract teachers from all over the country, even though we only provide a modest stipend and cannot pay for travel costs. Of the 27 teachers who attended last summer's program, 14 were from Massachusetts, and the others came from nine different states including those as far away as Texas, Minnesota, and Louisiana.

Like all our programs, our staff included UMass faculty, who are the content experts: Mark Tuominen (Physics), Jonathan Rothstein (Mechanical and Industrial Engineering), and Mort Sternheim (STEM Ed). It also included teachers who provide pedagogic expertise and knowledge of the classroom environment: Rob Snyder (Brookline HS, retired), Jennifer Wellborn (Amherst Regional MS), and Holly Hargraves (Hampshire Regional MS, retired). STEM Ed Project Manager Marie Silver made everything work smoothly.

Because the field is so new, there is only a limited amount of relevant curriculum material available. Nevertheless, we have been able to adapt or create engaging materials that can be integrated into a variety of classroom settings. The teachers create a nanofilm using inexpensive materials, and model an atomic force microscope with rulers and laser pointers. With UV lamps and UV sensitive beads they observe the effects of nanoparticles in sunscreens. The diffusion of food dyes in gelatin models the absorption of nanomedicines in body tissues.

The curriculum materials and 2014 institute applications are online at www.umassk12.net/nano.

"*The material is not too deep or shallow; it is just right. I have really enjoyed all the activities and will be able to incorporate them into my classroom. It is funny that with such simple tools we can incorporate some real world examples into the classroom and spark the kids to learn. Thank you so much for this awesome program*"

Science and Engineering Saturday

January 25. Going Down the Powers of Ten Scale. Rob Snyder, STEM Ed; Jennifer Welborn, Amherst Regional, Mark Tuominen, Physics; Jonathan Rothstein, Mechanical Engineering. Students find it easier to go up the powers of ten scale than down. How can they visualize microscopic and submicroscopic objects? We will explore hands-on ways to “see” and measure down to the nanoscale, including modeling an atomic force microscope. We will also discuss applications of nanotechnology to computers, solar energy, and medicine.

February 1. The QuarkNet Data Portfolio: Using Data from 21st Century Experiments to Teach Entry-level Physics and Physical Science. Tom Jordan, Fermi National Accelerator Lab and Guest Researcher, UMass. 21st century physics can seem obscure and esoteric. Experiments at the Large Hadron Collider have written 75 petabytes (75×10^{15} bytes) of data in just three short years. "Big Data" is in the public eye in news stories about Amazon, Google or the NSA. QuarkNet has partnered with experiments at Fermilab, CERN, LIGO and others to gain access to datasets and created a Data Portfolio: a suite of investigations that allow students to explore the data and the physics encoded in them. Students can explore momentum conservation, mass-energy equivalence, pattern recognition, histogramming, and other topics using these data. The investigations range from simple to complex, from using paper-and-pencil to web-browsers, and from tens of minutes to days. The investigations allow the students to explore 21st century data and appreciate that they can study some aspect of even the most esoteric experiments. They can access Big Data and ask their own questions.

February 8. Unleashing the “T”: Social, Mobile & Connected, Enhancing STEM with Technology. Sarah Dunton, Girls Inc. of Holyoke. Students will engage with technology and web-based programs that will enhance and enrich STEM lessons in their classroom, on fieldtrips and in informal educational settings. Technology should work for us and deepen our experiences as teachers, while acting as a tool that scaffolds learning for students. Using tablets, laptops and smartphones participants in this session will try some new online tools, consider the potential of social networking in STEM education and explore ways to utilize the “T”. Participants will create an exploratory lesson plan that will include the use of one or more of the hardware or software tools explored in this workshop. Participants should bring smart phones, lap tops and tablets (iPads) if they have them. We will have a limited number of iPads.

March 1. The Biological and Technical Bases of Plant Engineering. Alice Cheung, Biochemistry and Molecular Biology. Plants are probably the most manipulable and manipulated higher organisms on this planet. For centuries, farmers and scientists have bred plants in the hope of obtaining new species with more desirable qualities. In the last half century, studies on the fundamental biology of plants and the microbes that affect them for one reason or another, e.g. for symbiosis or as disease agents, have revolutionized how plants can be engineered to the advantage of world agricultural needs. I will discuss the molecular basis of how plant engineering is achieved, the physiological basis that underlies the success of the molecular manipulation, and the genetics that ensure preservation of the introduced qualities. There will be some demonstrations of the experimental processes and some on-hand activities. Materials for classroom exercises will also be made available to teachers upon request and the necessary material transfer agreements between institutions.

March 22. Seeing Beyond the Visible. John Pickle, Concord Academy; Rob Snyder, STEM Ed; Don Blair, Physics; Stephen Schneider, Astronomy. A bit less than half the light from the sun is in the visible part of the spectrum. Most of the remainder is in the near infrared, and a few percent is in the ultraviolet. We will explore how your eyes and a camera can “see” beyond the visible. Bring a laptop and a digital camera if you can. If your computer does not already have the Google Chrome browser, please install it and get the Webcam Toy app. Also, download and install the Analyzing Digital Images software from www.umassk12.net/adi.

March 29. Weather Makeup if needed.

April 26. Recall for those registered for graduate credits. Hasbrouck Lab.

Graduate credit option: There is a charge of $300 for 3 graduate credits plus a $45 registration fee; register for Nat Sci 697A (Cont ed) or 697 F (University). This is in addition to the $120 STEM Education Institute fee. Teachers may obtain credit for the seminar as many terms as they wish, but only 3 credits may be applied to UMass Amherst degrees. A lesson plan and a book report will be required for those enrolled for graduate credit. We will have Continuing Education registration forms at the first seminar.

Questions: Mort Sternheim, mort@umassk12.net, 413-545-1908, www.umassk12.net/sess

Online seminar registration and payment: www.umassk12.net/sess/register.html. Required for everyone whether or not they are registering for graduate credit.

Calendar of Events

Spring 2014 STEM Tuesday Seminars

STEM seminars are held at 4PM on the first and third Tuesdays of each month in Hasbrouck 138. All are welcome; no reservations are needed, and there is no charge. Parking is available in the Campus Center Garage.

February 4
Dr. Jenny Ross
Associate Professor, Physics, UMass
"Getting Together: Easy Ways to Improve Teaching in your Department"

February 18
Penny Noyce
Trustee of the Noyce Foundation
"Integrating STEM With Literacy"

March 4
Cathy Helgoe, *LEGO Education*; **Karen Sullivan**, *For Inspiration and Recognition of Science and Technology (FIRST);* **Renee Fall**, *Commonwealth Alliance for Information Technology Education (CAITE);* and **Sarah Dunton**, *Girls, Inc.*
"LEGO Education-Supported Outreach Programs for Girls"

March 25
Whitney Hagins
MassBioEd, BioTeach Mentor & Program Coordinator
"BioTeach and Beyond"

April 1
Sarah Dunton, *Director of Education, Girls, Inc. Holyoke;* **Simi Hoque,** *Assistant Professor, Environmental Conservation, UMass*
"Eureka!"

April 15
Adam Norton
Professor, UMass Lowell
"Artbotics: Attracting Students to STEM"

Nanotechnology Professional Development Institute

Monday to Friday, July 7 - July 11, 2014 at UMass Amherst

- Funded by the National Science Foundation
- Sponsored by the STEM Education Institute and the Center for Hierarchical Manufacturing
- Middle and High School Science, Math, and Technology Teachers
- $75/day stipends ($375 total), materials, parking, some meals
- Housing (new air conditioned dorms) for those outside the commuting radius
- Graduate credits available at reduced cost; free PDP's (Professional Development Points)

Website: www.umassk12.net/nano

Patterns Around Us Professional Development Institute

Monday and Tuesday, June 30 - July 1, 2014, plus 1 Autumn Saturday Recall

- At UMass Amherst
- Funded by the National Science Foundation
- Small group of ~8 teacher
- General science, biology, physics, technology/ engineering
- Housing for those outside the commuter area, parking, lunches
- $250 summer stipend; $75 Saturday recall
- PDP's

Benjamin Davidovitch, UMass Physics; Narayanan Menon, UMass Physics; Jennifer Welborn, Amherst Regional Middle School; Wayne Kermenski, Mohawk Regional School

Website: www.umassk12.net/patterns