Educational Goal

In this era of public policy decisions that hinge on a significant understanding of the science behind the issue – cloning, embryonic stem cell research, global warming – it is essential that we as scientists help the general population overcome their misconceptions about and unwarranted fear of science. My educational goal is to teach a chemistry course based on forensics mysteries that have been popularized by forensics TV shows and movies that will attract students who otherwise would avoid taking a science class.

Last spring I taught a 180-student section of general chemistry. On the first day of class I asked "Who likes forensic television programs like CSI (Crime Scene Investigations)?" More than 50% of the students raised their hands. For the past two years I have ridden the bus to and from campus. I frequently ask passengers about their favorite television programs. Forensics programs often top their lists, even if they later tell me that science scares them. Despite this cultural ioconography having taken a strong hold in the American psyche, no courses on our campus or in our region of the country have taken advantage of the natural segue of forensics into scientific education. If we harness the Hollywood-generated interest, we can teach the science behind the mysteries.

To take advantage of the forensics frenzy, I propose a general education course called *Crime Scene Chemistry: The truth and lie behind CSI*. Undoubtedly student interest in this course will be tremendous. It not only will provide an opportunity to teach students who would otherwise not take a chemistry course, but will provide a platform for raising interest in learning scientific principles. In conjunction with this course I have made arrangements with the regional transit authority to launch a public awareness campaign called "*Crime Scene Chemists*" (see attached letter). Posters in all regional buses will engage riders in solving forensic mysteries and learning the chemistry behind their solutions (Fig. 6). This opportunity to influence their perceptions about science, and shape their understanding of scientific concepts ought not be missed. The *Crime Scene Chemists* course and public transit campaign will significantly impact the goal of broader social interaction with science.

Figure 6. An example of a Crime Scene Chemists poster that will be displayed in PVTA buses.

Educational Plan

Design of course. I plan to develop and teach an undergraduate general education course *Crime Scene Chemistry: The truth and lie behind CSI*. Currently there are no forensic chemistry courses and only one general education chemistry course offered at the University of Massachusetts Amherst. A general education chemistry course, CHEM101 has been significantly overenrolled (up to 1000 students) in every semester it has been taught (1975-2007). The combination of the appeal of a course in forensics, and the opportunity for students to fulfill a science requirement, are nearly certain to make *Crime Scene Chemistry* an oversubscribed class as well. During the first year of the course, enrollment will be capped at 200 students. In future years, enrollment could be increased to as many as 380 students. If the course is as popular as we expect, multiple sections could also be offered. The plan for this course has been endorsed by my department head and could be taught in perpetuity.

The first day of class will be a day of heightening interest. Clips of 8-10 of the most scintillating crime mysteries, for which there are chemical explanations, will be shown, with the promise that explanations will be possible after we learn a little more chemistry. The first week we will cover the basics of atoms, molecules and the scientific method. At

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the end of each week one movie or episode from a forensics serial will be screened in the Campus Center Theater. The screening itself will not occur during class time, and will not count for course credit, however the students will be required to write a half-page essay discussing chemical mysteries they observed in the screening. Students will also be encouraged to suggest chemical mysteries that they would like to explore in future weeks. These assignments will be turned in electronically on the course web site (managed by UMass SPARK) so that I can see them prior to the Monday meeting of the class. During the week, I will refer back to the chemical mysteries that Hollywood has provided for us. For example, during the week when we study the gas laws, the students will view the CSI episode 'Scuba Doobie Doo' in which a charred scuba diver is found atop a burned tree in the desert. This mystery will prompt excitement about PV=*n*RT. Other topics in this course will include: intermolecular forces, colligative properties, reaction kinetics, atmospheric chemistry, the chemistry of DNA, DNA sequencing and more.

My goal for *Crime Scene Chemistry: The truth and lie behind CSI* is not solely that students who would otherwise avoid chemistry altogether learn some chemistry, but more importantly that they are inspired by the idea that understanding science will help them comprehend the world around them better. Mysteries are not inexplicable phenomena, but comprehensible results of causality, and if we just dig a little, we can understand important debates over topics like global warming and stem cells.

Public transit campaign. In the Pioneer Valley of Western Massachusetts (population 680,000) public transportation is a way of life. With over 2.5 million riders per year, and an average of 200,000 riders per month in the northern region alone (Fig. 7), the Pioneer Valley Transit Authority (PVTA) boasts some of the busiest bus routes in the country. Advertisements on PVTA buses are thus one of the best ways to impact a large cross section of the community. PVTA has supported this project (see attached letter) and has agreed to host the *Crime Scene Chemists* campaign free of charge on PVTA buses. Posters like Fig. 6 will be posted in all PVTA buses on a space available basis. New posters will be displayed bi-monthly and will be cycled onto display placards throughout the year. Each poster will describe a forensic mystery. Some posters will display characters discussing potential explanations. All posters will direct readers to visit http://crimescene.chem.umass.edu for the answer to the mystery. For example, on the website section corresponding to Fig. 6, the true case of the disappearing fingerprints will be described. The explanation is based on the intramolecular forces that hold together fatty acids (the compounds secreted by the sebaceous glands that leave the fingerprint residue)[52]. The difference in the composition of these fatty acids in adult and children's skin results in differing rates of fingerprint disappearance. This is why the little girl's fingerprints vanished after just four days, whereas adults fingerprints can stay intact for months or years. The website will be written for a general audience, and will contain ample graphics and metaphors (e.g. intermolecular forces likened to Velcro). Lisa Korpiewski, the chemistry department graphics designer, has agreed to design the posters. Hardy will provide the content and maintain the website. Hardy has designed and currently maintains two course websites and her lab website http://people.chem.umass.edu/jhardy/, so is capable of maintaining the *Crime Scene Chemistry* site. Given that posters can be inexpensively designed by chemistry department personnel, can be reused, and will be displayed free of charge, this public transit campaign is eminently sustainable over a many year period extending well beyond the timeframe of this award. Since 80% of all UMass students also ride the bus, the *Crime Scene Chemists* campaign is also a great way to advertise the course to the target audience of non-science majors.

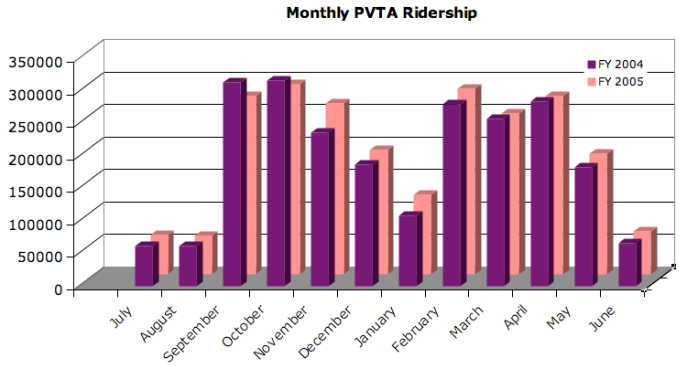

Figure 7. PVTA Northern Region ridership impacted by the *Crime Scene Chemists* campaign on the PVTA buses.

Impact on society. Many of the riders on public transit are underserved individuals, groups and communities, particularly individuals who do not own cars. Particularly in Holyoke and Springfield, MA, two economically-challenged cities served by PVTA, there are many bus riders who have no routine contact with science, and little connection to any opportunities for scientific education. The *Crime Scene Chemists* campaign will enhance scientific literacy within this segment of the community by taking advantage of a culturally popular topic.

Impact on undergraduate education. Due to the popularity of forensics television shows and movies, I predict that the course *Crime Scene Chemistry: The truth and lie behind CSI* will be an extremely popular course, attracting many

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students who typically would not chose to take a chemistry course. As in the general chemistry course I taught in the spring 2007 term, I will relate mysteries from crime scenes to mysteries we have in my lab, centered around design of allosteric sites in phosphatases. This will underscore to them that being a scientist is being a detective on a molecular scale.

Impact on undergraduate training. My laboratory is a training ground for undergraduates, especially under-represented minority undergraduate students. I have trained two African-American undergraduate students, one Hispanic, two caucasian and one asian undergraduate. One of the African-American students has just graduated and is working in the pharmaceutical sector. The other graduated in Spring 2006 and is now a research technician at Brigham and Women's hospital. She will enter graduate school in Public Health this fall. A Puerto Rican student starting graduate school this fall, first came to my lab as a participant in the NSF Summer Program for Undergraduate Research (SPUR) program. Currently two undergraduate students also work in my lab. Both of them are well on their way to publications from their work.

Unique aspects of *Crime Scene Chemistry*. How is this course different from other forensic science courses being developed around the country? Most forensic science courses, and all available forensics chemistry texts, are offered at the upper division[53-56], which requires substantial background and course work in chemistry. Thus even though many students would love to take a course based on their forensic fascination, the number of prerequisites prevents them from enrolling. As a Cottrell scholar Seth Cohen at UCSD developed a fantastic once-a-week freshman seminar course that was available to students from across campus, regardless of their major. I have spoken with Prof. Cohen and obtained his syllabus and the resources he used for his class. The course I have designed differs from both of these types of courses in that it is offered as a three-day per week general education elective to students regardless of major, so it provides enough time and depth that many important elements of traditional chemistry can be taught. The most successful aspect of my course last year was always when I could bring in real world mysteries from my own life and research. Learning to calculate blood alcohol content as a function of weight and blood volume was extremely popular with my students, so I see that forensics mysteries will likewise be captivating. The forensics theme provides a unique twist that allows me to make connections between science and their own lives and provides a platform for more detailed discussions of various chemical mysteries. Most importantly, it provides the motivation to students who love forensics but think they are "scared of" or "bad at" science to learn a subject that may not come naturally to them. When they see the application of chemical principles to their favorite TV shows, it doubtlessly seems more relevant to study.

Assessment Two main types of assessment, overall and day-to-day, are important in the development of *Crime Scene Chemistry*. Overall success in the course will be assessed by pre- and post-course quizzes that will be developed by Peterfreund Associates[57], a nationally recognized educational consulting firm. Our department routinely assess the success of classroom and on-line learning[58] in collaboration with Peterfreund Associates. The assessment quizzes will be given via OWL (the widely used on-line learning software developed here at UMass). Peterfreund Associates will analyze the quizzes for overall comprehension, as a function of grade received, etc. to enable me to assess the success of the course in meeting my overall instructional goals.

Day-to-day assessment of understanding will be analyzed by Personal Response System (PRS) transponders. The University of Massachusetts was one of the earliest adopters of the technology and has extensively evaluated the effect of PRS on teaching and learning[59]. In particular it is encouraging that the PRS technology allows small class techniques to be employed even in large classes[60]. During the course I taught last spring, I became even more convinced of their effectiveness in stimulating participation. Not only does the interruption provide a useful break in the lecture, I noted that PRS questions helped students focus more intently on the material presented. I piloted a program in peer instruction based on the work of Mazur[61,62]. In my course I used a combination of concept questions and numerical calculations for PRS. The first time I asked a question that only 20% of the students could answer correctly, I employed Mazur's technique. I asked the students to discuss the problem with their neighbors and re-enter their answers. I was astounded that the correct responses jumped to 80%! I have seen the way that discussions during peer instruction can dramatically increase overall understanding. In *Crime Scene Chemists*, I plan to use and improve upon the PRS-based peer instruction method I have already implemented in my teaching.

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