Focus On Microbiology Education

N E W S M A G A Z I N E

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AMERICAN SOCIETY FOR MICROBIOLOGY

FEATURES

This issue of *FOME* focuses on *service learning*. One of our authors, Bruce Alexander, quotes Pamela and James Toole's definition: 'Service-learning is a form of experiential learning where students apply academic knowledge and critical thinking skills to address genuine community needs.' A frequent service-learning experience is using our students as teachers in K-12 classrooms. Several articles in this issue describe such experiences. Other service-learning activities involve our students in addressing actual community problems, as described by Marion Fass in her Feature article, below. Many of us have seen growing participation in service learning on our campuses. We hope one of the many stories shared in this issue give you insight and stimulate your own ideas around service learning.

You'll also notice that we have a brand new updated logo! Thanks to Kristen Catlin-LeBaron, our ASM production editor, for sharing her graphic arts talent with us.

Kelly Cowan
Editor, *FOME*

Connecting Microbiology With the World Outside: Constructing Opportunities for Authentic Learning in the Classroom and the Community

Marion Field Fass
Beloit College

Each of us, as microbiologists, easily acquires new knowledge in our field by connecting "the new" with older concepts and models that we use to structure our understanding. Just as we have collections of slides and PowerPoints and scenarios for explaining difficult material, we also have organized systems within our brains that allow us to accumulate microbiological facts more easily than our novice students. New research on cognitive science demonstrates that it is this schema of knowledge that differentiate expert from novice (1).

Any comments, questions or suggestions for the Focus on Microbiology Education newsmagazine? Please e-mail us at:

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Complex cognitive structures develop from knowing the facts and knowing how to apply them to solve problems. They are strengthened by the rich experiences of professionals in their fields. An illustration of the advantage that experts have in acquiring new information can be seen in a cognitive behavior study that contrasted the ability of chess masters to remember the location of pieces on a chessboard with that of naïve chess players. The experts, who knew what a chessboard meant, remembered the location of more chess pieces than the novice, for whom the board was just a set of unrelated pieces (1). As we face the challenge of educating students for understanding and retention, and not just memorizing the facts, we need to ask how we can help students structure their knowledge so that they can use and apply the concepts they learn in different arenas.

My goal in the classroom, in the laboratory, and in establishing field experiences for students is to reinforce factual understanding by connecting microbiology to students' lived experiences.

How People Learn, the National Research Council report on applying cognitive science research to the practice of learning, suggests that "relevant knowledge helps people organize information in ways that support their ability to remember"(1). We can do this by building on the experiences that students bring to the classroom, by building engaging experiences in the classroom, and by structuring experiences that enable students to bring their microbiology skills to community problems.

I recently asked my Introductory Microbiology students what had engaged them in the study of microbiology. I teach a class of 20, so discussion is easy. Students mentioned laboratory experiences and simulations as the aspects of the class that made microbiology meaningful. They want to *see* microbes—even if we tell them that they are "unseen"—and they want to see what they do.

More than any other activity, students mentioned the value of the exploratory laboratory on Microbial Diversity from Handelsman *et al.*, *Biology Brought to Life* (3), in which students grow microbes from soil samples on four different selective media. The diversity of microbial life that emerges from soil is amazing, and the changes that the students can track over the period of two weeks reinforce difficult concepts like selective media, microbial competition, communication, and succession. We often assume that students are able to visualize the microbial world and its interactions, when they are still looking for proof of its existence.

My goal in the classroom, in the laboratory, and in establishing field experiences for students is to reinforce factual understanding by connecting microbiology to students' lived experiences. The fermentation of Korean *kimchee* is a laboratory experiment that introduces students to industrial microbiology in a multicultural context and gives them ways to safely manipulate experimental conditions. In this activity microbial growth and metabolism can be studied quantitatively (2), and students can explore the connections between the addition of fish and peppers to *kimchee* and the impact of altering nitrogen supply and inhibitory compounds on microbial growth. (NOTE: Students only eat their *kimchee* when prepared outside of the laboratory!)

Real world events provide microbiology educators with invaluable assets for constructing learning experiences that enhance understanding and recall. Analyzing complex everyday situations provides structures upon which students can organize their learning as they move from being novices to being experts. I recently used a case study of the control of citrus canker (5), based on actual events in South Florida, to guide students through the application of microbial control strategies using concepts of pathogenicity, epidemiology, and genomics. The case study also reinforced the importance of considering economic and political issues. Students in the classroom became engaged with the biology and with the complexities of control, an experience enhanced by the fact that there *wasn't* a clear answer to what was best for the community.

> **During study-abroad experiences, students have conducted a range of projects, from examining the risk factors for fungal infection of cacao trees in Costa Rica to assessing access to STI information and treatment in Tanzania to analyzing availability of clean water in Kenya.**

Case studies (and the opportunity for connected learning) lie in the microbial news that confronts us daily, from the recent outbreak of Hepatitis A in Pennsylvania to the concerns in Wisconsin about the risks of "chronic wasting disease" in deer and its unpredictable impact on hunters and their families. Far from our shores, millions of people are suffering from HIV/AIDS, an uncontrollable but preventable disease that is complicated by a range of biological as well as social and cultural factors. Another good source of activities is *Microbes Count!* by Jungck, *et al.*, which uses case studies and real world issues to provide students with the opportunity to use quantitative reasoning and microbial knowledge in proposing solutions to these and other problems (4).

Service Learning

For microbiology students, service learning experiences can also enhance their understanding of science and its applications. One definition of service learning is *experiential learning that aims to solve problems with the input of the community*. Just like laboratory activities, service learning opportunities need to be carefully constructed to lead students through the application of knowledge in solving problems. They should also include a reflective segment so that students are able to connect their activity to classroom learning. Service learning activities differ from the laboratory activities in most introductory courses in that student work is designed to contribute to the solutions of real problems faced by the agencies or communities in which they are carried out.

Our communities are full of potential experiences for students—from assisting day care centers to improve their methods of sanitation to collaborating with local health departments in assuring water quality or reducing the risks of vector borne diseases. The development of effective service learning opportunities relies on close relationships between teachers and the community. The effectiveness of service learning placements can be maximized by establishing long-term relationships with agencies and by establishing projects that generate longitudinal data or regular assessments. There are many examples of microbiology service projects already taking place. For instance, the students of Dick Fluck, a biochemist at Frankin and Marshall, have studied tuberculosis control in rural Pennsylvania and provided data upon which new policies have been based. Students of chemist Garon Smith at the University of Montana at Missoula have monitored water quality for that state. Both of these scientists have been involved with the SENCER project of Association of American Colleges and Universities. SENCER (Science Education for New Civic Engagement and Responsibilities) has a website of model courses that link science and the development of strategies to deal with community problems (www.aacu.edu/SENCER/models.cfm).

Beloit College students have carried out service learning projects both in the community and during study abroad. They have assisted the local health department to assess public knowledge of both bioterrorism and of West Nile virus and have studied the distribution of disease using Geographic Information Systems (GIS). During study-abroad experiences, students have conducted a range of projects, from examining the risk factors for fungal infection of cacao trees in Costa Rica to assessing access to STI information and treatment in Tanzania to analyzing availability of clean water in Kenya. An important part of all of these projects has been writing about them upon their completion. This allows students to give data back to the community and to reflect upon methods, successes, and limitations.

There are, of course, limits to what students can do in communities through service learning projects. Students are not professionals and are better suited for assessing situations and gathering information than for developing programs. But they can collect valuable information and assist communities to use it in making decisions.

An understanding of current microbial issues and threats can help students construct a framework for understanding the abstract world of microbial life. As educators, our challenge is to help students appreciate the complexity of relationships in the microbial world and to see how they can apply their newly developing scientific skills and understandings. As teachers of microbiology we have the time in lectures, laboratories, and discussion sections to actively connect learning to authentic problems. As shapers of curricula and major programs, we have the opportunity to promote the use of case studies and service learning. No one knows better than microbiologists about the

> **An understanding of current microbial issues and threats can help students construct a framework for understanding the abstract world of microbial life.**

risks of disease in parts of the world where harsh climates, limited access to clean water, and poor access to health services increase humans' susceptibility to infectious diseases. The challenge of the 21st century is to use science constructively in building a sustainable lifestyle for all the citizens of the planet.

References

1. **Bransford, J., et al., (ed.).** 2000. How People Learn: Brain, Mind, Experience and School: Expanded Edition. National Academy Press, Washington, D.C.
2. **Greenler, J.M. and R.M. Greenler.** 2003. Exploring Microbial Fermentation with Korean Kimchee, p. 251-259. *In* J.R. Jungck, M.F. Fass, and E.D. Stanley (ed.), Microbes Count!: Problem Posing, Problem Solving and Peer Persuasion in Microbiology. American Society for Microbiology Press, Washington, D.C.
3. **Handelsman, J.** 2002. Microbial Diversity, p. 35–39. *In* J. Handelsman, B. Houser, and H. Kriegel (ed.), Biology Brought to Life. McGraw-Hill Custom Printing.
4. **Jungck, J.R., M.F. Fass, E.S. Stanley (ed.).** 2003. Microbes Count! Problem Posing, Problem Solving and Peer Persuasion in Microbiology. American Society for Microbiology Press, Washington, D.C.
5. **Weinland, L., P. Woodruff, M. Waterman, and E. Stanley.** 2003. Citrus Canker: Alternatives for Control, p. 279–284. *In* J.R. Jungck, M.F. Fass, and E.D. Stanley (ed.), Microbes Count!: Problem Posing, Problem Solving and Peer Persuasion in Microbiology. American Society for Microbiology Press, Washington, D.C.

NUTS AND BOLTS

Service Learning in the Undergraduate Science Curriculum: Partnering College Students with High School and Middle School Classes

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As a teaching scientist my days are more than full. Over time, however, I have learned to keep an open mind when enthusiastic students approach me for help with things that go beyond the scope of microbiology. Often their requests lead, push, or drag me to places I never thought I'd go. In the process—and here's the kicker—I usually learn something, and I am invariably reminded of why I am willing to work so hard with these young people.

At first, I considered it a pain in the neck, having my students go to a local school and teach something. Undergraduates would approach me with this "new" idea, and little else: no plan, no connections, and no context. Finding a local teacher who was willing to put up with my students in her/his classroom, figuring out the format and topic of the teaching, and ensuring that things went well were challenges that we (many times I) met in one serendipitous way or another. But despite the extra work and hassles, I was often amazed at the outcomes. Teachers would comment on the effectiveness of having a college student as a teacher and role model for younger students. Sixth graders would peer into microscopes and call their friends over to see what "cool thing" they had found. High school students who had never set foot on our campus would come to visit their undergraduate mentors. My students would tell me how hard they had to work to really understand what they were presenting in order to be prepared to answer questions. It seemed that the student outcomes (on both sides) were too good to ignore. I decided to explore ways of making these projects really beneficial to teachers and more logistically reasonable for me to oversee.

To that end, I enlisted the help of a colleague in our Center for Service Learning. A former teacher and principal herself, she explained that teachers are struggling to make their curricula comply with the "Maine Learning Results," a set of standard topics and concepts that have been established by the state as required curriculum. The standards are arranged by general discipline and for each grade level indicate what students should know or be able to do by the time they complete that level. In the sciences there are many issues that make it difficult for teachers to align their lesson plans to the Learning Results. Many teachers are not familiar with "new" topics such as biotechnology or cellular and molecular biology. Shrinking school budgets often make it all but impossible for teachers to take advantage of workshops and seminars that would bring them up to speed. Laboratory spaces are scarce in public schools in Maine, and where they do exist, they are outdated and woefully under equipped. We decided to get some teachers together and ask what kind of help they needed most. The answers varied. Some wanted help designing particular projects or lesson plans that they had been thinking about. Others wanted to know what resources are available on the web. Some wanted help designing labs that require minimal equipment and facilities. All were intrigued by the prospect of free undergraduate labor, and all agreed to participate. In 2000, I taught a beginning biology class with 40 students who participated in 11 different Partnerships. I have since recovered and generally try to keep the num-

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ber of Partnerships to a more manageable number (from one to six a year).

The notion of "Learning Partnerships" suggests that this kind of arrangement can be good for everyone involved if we consider each other learners as well as teachers. The learning, of course, goes far beyond the science content that is always a central focus. I have learned that the Partnerships work best when the teachers tell us what they need and we collaborate to formulate a plan to meet those needs. I have learned to keep track of what students are doing by requiring detailed proposals, one-page bi-weekly progress reports, and short weekly meetings. I have learned that when you help one teacher develop a lesson plan, you actually help many because teachers talk. I have learned that there truly is some magical connection between young kids and college kids and that even a professor can become a part of that magic because it comes from a deep generosity of spirit.

In these times of rising standards and falling budgets, the salvation of education lies in its one limitless, renewable resource: the work of dedicated teachers. Collaborating with our middle and high school teacher colleagues has been enjoyable and very rewarding from many perspectives. I can now honestly encourage my own students to consider teaching science as a career and can introduce them to people who do it well. Establishing Learning Partnerships has become a regular part of my classes. More often than not, they are win-win situations.

Activities to Promote Learning in Microbiology

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Students learn in different ways and, as teachers, we need to design strategies to aid the different types of learners. The activities described in this article focus on microbiology students, but similar activities can be created for students in any discipline. I have found that students who participate in such activities learn more microbiology and enhance their education in other ways.

As a way of showing these students how microbiology can be applied and informing them of opportunities in the field, we formed the Leeuwenhoek Society, a student branch of the American Society for Microbiology.

I am a member of the Department of Natural Sciences at the University of Houston-Downtown (UHD), an urban, commuter campus of over 10,000 primarily undergraduate students. There are usually 40–50 microbiology majors in the department. We teach a general microbiology course for 60–70 students during the fall semester, a clinical microbiology course for 25–35 students during the spring semester, and are introducing a non-science microbiology course in the Spring 2004 semester. In addition, several upper-level courses are offered on a rotating basis with approximately 20 students each. As a way of showing these students how microbiology can be applied and informing them of opportunities in the field, we formed the Leeuwenhoek Society, a student branch of the American Society for Microbiology (ASM). We found that such organizations used wisely can have an enormous impact on a student's learning and the student's ability to make informed career choices. Described below are several projects that the Society has undertaken.

1. Teaching Project: To introduce microbiology to fifth graders, the Society partnered with a UHD graduate who is teaching at a local elementary school. This program is useful for two reasons: 1) our students strengthen their knowledge by teaching the material; and 2) we introduce microbiology to students at a young age. Microorganisms are ubiquitous and serve vital functions, but most people are unaware of them or have the misconception that they are only harmful "germs." Three to four of our students conduct a 45-minute session in the fifth-grade classroom each week for four weeks. The students and I design short, interesting lectures and simple experiments in which the fifth graders can participate. Before-and-after surveys completed by the students demonstrated that they had learned about microbes and enjoyed this learning experience. As a bonus, the elementary students began to identify with the college students as role models. Our students gained the invaluable experience of teaching and enjoyed the satisfaction of helping the younger students. Two UHD students presented the results of their efforts at local conferences. As a result of the success of this project, we have received requests to conduct other such short courses. We hope to obtain external funding and to expand the project to other area schools.

2. ASM Texas Branch Conference: The Leeuwenhoek Society members participated in the annual Texas Branch microbiology conference held each March. This conference focuses on undergraduates and is an ideal place for our students to learn about conferences, meet colleagues and researchers from other institutions, and gain confidence in making presentations. In the last two years, approximately twenty students have attended the conference and several students have made poster presentations—two of them have won prizes for their research. Participation in this conference and other conferences has sparked an interest in research, which is crucial to the students' success in the sciences.

3. Microbial Jeopardy: A fun-filled activity in Jeopardy format, this game actively tests the students' knowledge in microbiology and related areas. Groups of four to five students participate in this game, which is held under a strict set of rules. The students enjoy the competitive spirit of the game, while simultaneously identifying topics that require more study as well as the most likely students in their peer group from whom they can obtain assistance. The students love the Jeopardy format and this annual event has now been expanded from Microbial Jeopardy to Science Jeopardy. This past fall the event was held on October 31^{st} and students dressed in Halloween costumes.

4. Field Studies: The students in our Society take field trips to various locations, including hospitals, industrial plants, and ecological collection sites. Recently, we visited a wetland and a state park. The students learned how to collect soil and water samples and process the samples in the lab. Two students continued the wetland project, isolating and identifying several bacteria. Studies of soil samples from our local state are in progress.

5. Career Fair: We organized a Career Fair in Microbiology and Chemistry and invited speakers from industry and academia. In a daylong session, the speakers informed the students about careers in industry, research, and medicine. Students had an opportunity to talk to the speakers and some students maintained contact with individual speakers in order to obtain specific advice.

The Leeuwenhoek Society also holds social functions and fundraisers. I have found all of these activities to be excellent for teaching students about microbiology and the value of research and for informing them of career opportunities. Additionally, the students have formed study groups and have gained self-confidence. These students are interested in their studies and proud of their accomplishments.

A Rural Science Education Partnership—the Maine ScienceCorps

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Since the 2001-2002 academic year, the educational activities of immunology and molecular biology graduate students at the University of Southern Maine (USM) have gone far beyond university classrooms and research laboratories to reach into high school science classes in some of Maine's most isolated rural high schools. With support from the National Science Foundation's Graduate Teaching Fellows in K-12 Education program, the graduate students participate in a program called the Maine ScienceCorps and collaborate with teachers in eleven rural high schools to provide laboratory-based active learning experiences that would otherwise not be possible with the limited resources available. Science teachers in Maine's rural high schools are generally challenged by professional isolation, limited access to the scientific world beyond the classroom, and minimal laboratory resources. Under these conditions it is particularly difficult for the rural teachers to meet state mandates to align curriculum with the science education standards articulated in the Maine Learning Results which are based on the National Science Education Standards. The Maine ScienceCorps, founded in 2001 to address these common needs among rural schools, provides a model of effective outreach that enriches the educational experiences of both high school and university students while connecting the high school teachers to the university scientific community. So far this educational partnership has involved 16 graduate students, more than 30 teachers, five scientists from the university's Department of Applied Medical Sciences, the education division staff of the Foundation for Blood Research in Scarborough, Maine, and more than 2,500 Maine high school students.

ScienceCorps fellows, typically working in teams of two, make regular visits to eleven high schools widely distributed across the state where they present scenario- or case history-based laboratories that teach concepts involving nucleic acids, proteins, microbes, viruses, human disease, and immune responses. The demands of the outreach experience are significant and present challenges in balancing these duties with graduate course work and research. It is generally only students who have completed the first and most intense year of course work who are chosen by a faculty selection committee to become ScienceCorps Fellows. Most teams of fellows are assigned to work with teachers and students at two participating high schools. Visits to five of the eleven schools require travel between 200 and 330 miles one way and consequently involve overnight stays for the fellows. Visits to the other six schools usually can be done without staying overnight. Extensive communication occurs between the fellows and the cooperating teachers between visits to coordinate integrating the planned activities into the curriculum. Laboratory-based activities aligned with the Maine Learning Results are provided to each school in eight to ten ScienceCorps visits during an academic year. Planning and preparation of lab materials generally involves extensive effort because almost all supplies and equipment are transported to the classrooms. Activities are frequently modified and adapted to fit the

> **The Maine ScienceCorps provides a model of effective outreach that enriches the educational experiences of both high school and university students while connecting the high school teachers to the university scientific community.**

curriculum of specific classes and the time constraints presented by each school's class scheduling. In the classrooms every student is directly involved in performing the laboratory tasks themselves and then in interpreting their results.

This project has made major contributions to (i) enhancing the graduate education experience of immunology and molecular biology graduate students at USM through providing them with authentic laboratory-based teaching experiences in high school science classrooms and (ii) bringing scientific role models and advanced laboratory activities into some of the most remote and isolated rural classrooms in Maine.

The communication skills that the graduate students develop are reflected in their research presentations as well as in the high school classrooms. The teaching experience they gain is more extensive than that of most university teaching assistants. Through their outreach roles, the graduate students are prepared for future roles in the professoriate and are encouraged to collaborate in science education at all levels throughout their careers. After a year of participating in ScienceCorps laboratories brought to them by graduate students, the high school students even in a remote high school in northern Maine will know at least two scientists and will have experienced a sampling of the laboratory methods that are used in biomedical science.

The Maine ScienceCorps experience has made clear both successful strategies and the limitations and challenges that are encountered in bringing inquiry and lab activities into high school classrooms. Surveys indicate that the scenario-based ScienceCorps lab activities have stimulated the interest of most students participating, and teacher evaluations of the value to their classes has been overwhelmingly positive. Some teachers indicate—and student surveys suggest—that some students are influenced to aspire to scientific majors when they go to college. Several teachers have noted seeing increased interest in science among some of their students who are not ranked high academically and have generally been considered among the less motivated students. This may reflect the value of hands-on active learning for these students. The ScienceCorps experience illustrates that bringing active learning into the classroom through laboratory-based activities is quite valuable, but is easier than making the activities truly inquiry-based under typical classroom time constraints. Recent efforts are directed toward providing greater content linkage between the different laboratory activities to provide a more inquiry-based approach that allows students to experience how selected research questions can be investigated. A particular focus has been on developing a series of bacteriophage laboratories to convey knowledge of basic virology. These laboratories also lead students through basic molecular biological investigations using PCR, molecular cloning methods, restriction endonuclease digestion, and the basic bioinformatics of comparing DNA sequences with those in sequence databases.

FIG. 1. Students in the Maine ScienceCorps program.

ScienceCorps fellows have also provided support for the efforts of several teachers who are working to develop research projects and collaborations that can involve their high school students. Establishing small-scale collaborative research projects that actively involve students at selected schools is work in progress that reflects the long-term goal of creating opportunities for the high school students to experience scientific inquiry in direct and highly meaningful ways. Among the eleven participating high schools, some provide special opportunities in biotechnology education as part of the curriculum or as voluntary after-school activities. Faculty scientists and graduate students at USM are currently engaged in a collaborative research project with teachers and students at three high schools. This research interfaces with a developing research program at USM investigating lobster shell disease, a polymicrobial disease of ill-defined etiology that is characterized by degradation of the chitinaceous carapace of these economically important crustaceans. Epizootic lobster shell disease in southern New England and Long Island coastal waters in recent years has caused significant concern within the Maine lobster industry. Shell disease is a problem in biocomplexity involving complex microbial communities and myriad environmental factors that provides a rich framework for interdisciplinary scientific inquiry in the laboratory and the classroom. Students in an after-school biotechnology research club at Skowhegan Area High School and in biotechnology classes in the Augusta area are currently working to isolate bacteriophages that infect bacteria isolated from lobster shell disease lesions. The importance of bacteriophages in the ecology of microbial communities and the numerous precedents for their importance in bacterial pathogenicity suggest that study of shell disease from a virological perspective may be interesting. Students participating in this research project gain basic experience in research and learn research methods and much about the abundance and importance of bacteriophages in the environment. The collaborating teachers and graduate students will present their findings as well as their perspectives on this collaborative project at scientific meetings during 2004.

University science faculty and administrators view the ScienceCorps program as highly congruent with university educational, research, and public service priorities. Consequently the university is sharing in financial support of the ScienceCorps program and is seeking to sustain the program as an integrated component of graduate education in the sciences. Through collaboration in education and sometimes in research, the Maine ScienceCorps has significantly bridged the cultural divide between science education in Maine's secondary schools and its largest public regional comprehensive university. Targeted enhancement of research capacity at USM is linked to the educational priorities of providing for Maine a scientifically and technologically well-educated workforce that will drive regional economic development and diversity. It is increasingly recognized that to fully foster development of a scientifically and technologically well educated populace, the university scientific community must form partnerships with K-12 educators that will help in the preparation of new generations of citizens for higher education and a future that is technologically and scientifically demanding. The Maine ScienceCorps program and other initiatives involving partnership with secondary school science education are creating an environment for faculty in which scientific research, the scholarship of teaching and learning, and responsiveness to community and societal needs are all encouraged and rewarded. It is expected that all participants will benefit and improvements in the quality of teaching and learning will be evident in university classrooms as well as in partner secondary schools.

"Crossing Boundaries: Innovations in Undergraduate Research"

The Council on Undergraduate Research will hold its next national conference, "Crossing Boundaries: Innovations in Undergraduate Research," at the University of Wisconsin - La Crosse on June 23-26, 2004. This conference will bring together faculty, administrators, policy makers, representatives of funding agencies and others with an interest in doing and promoting undergraduate research. With over 100 workshops, presentations by representatives of funding agencies, disciplinary sessions, informal roundtables on current topics, and social interactions, this promises to be an outstanding conference.

For information on program and registration, visit www.cur.org/conferences.html

A Classroom Transformed Into a Lab: Microbiology for Elementary School

Elisabeth F. Maria Schlegel and Jorge Luis Muñoz-Jordán
Mount Sinai School of Medicine

Precious Curiosity

Children surpass adults in their natural curiosity and sense of wonder. They love to observe, ask questions, and experiment. Their curiosity is precious. It is a curiosity full of eagerly made observations, unspoiled expectations, and prejudice. Children learn by asking questions—some of those questions will be easy to answer, others will be hard.

Scientists also ask questions. Curiosity is the key word in science. The challenge of solving complex intellectual problems and the desire to contribute to human knowledge drives adult scientists. The generally accepted scientific method channels scientific curiosity. Knowledge is derived from observation, study, and experimentation. Scientists apply inquiry and skills to conduct their investigations and reach conclusions. It is important to teach children science-process skills as they foster problem solving and assist children in answering their own questions. Although many children do not realize it, they investigate natural phenomena and objects all the time. By answering their own questions and adding to their storehouse of knowledge, they are also simultaneously learning new information.

It is not only for passing the *Regents* and other standardized tests that the natural curiosity of children needs to be cultivated. As today's children grow up, they will need to be able to formulate an educated opinion on the exploding mass of emerging knowledge, whether they become scientists or not. Sadly, curiosity and wonder diminish as children progress through school. Without good science curricula, up-to-date labs, and support from scientific institutions, young children may not only fail examinations but may also be deprived of an intellectually satisfying approach to life itself. Science education has to start early—in elementary school (1).

Scientists Go Back to School—As Teachers

The Isidor and Ida Strauss School (P.S. 198) provides Pre-K to Grade 5 students with a cooperative learning environment and an intensive program filled with interactive activities that stimulate teamwork. The school is located on Manhattan's Upper East Side on the borderline between East Harlem and the Carnegie Hill area in the vicinity of the Mount Sinai Hospital and the Mount Sinai School of Medicine. Many parents whose children attend this school work at Mount Sinai, and naturally they are interested in their children's scientific education.

In the 2002-2003 school year, Mount Sinai scientists approached P.S. 198 staff with an offer to help further develop the science curriculum of the school. Fourth grade students in all New York City public schools are tested annually in the areas of mathematics, language, and science. Our initial assessment of the test results revealed that P.S. 198 students' performance was substantially better than the norm for the entire city. Generally, it was agreed that the steady progress and the good-to-excellent performance of the students in mathematics and language was proof of their great intellectual capacity and the competency of the staff. However, an initial assessment also revealed that the school's excellent progress in English and mathematics did not always correlate with its progress in science (http://www.nycenet.edu/daa/schoolreports/02asr/102198.pdf; Fig. 1).

Considerable effort was invested in evaluating and improving the situation. Revision of the science curriculum and improvements in its implementation were an important part of our mission, and teachers are now given better assistance and improved materials that will help them teach this curriculum (2). But the most ambitious project is one that brings scientists to the realm of P.S. 198. Under the name of "Science Week at P.S. 198," we have designed a program exclusively for this school. The program's goal is to transform classrooms into laboratories where children can conduct experiments that are supervised by instructors from various disciplines. A week of scientific activities was planned which included guest speakers from the nearby Museum of Natural History and the New York Hall of Science in Queens and scientists from Mount Sinai specializing in areas such as Communications, Space Science, and Microbiology. Because our base is the Department of Microbiology at Mount Sinai, we have received institutional support, and the School of Medicine has been extremely accommodating. For more information, please refer to our website (www.mssm.edu/ps198).

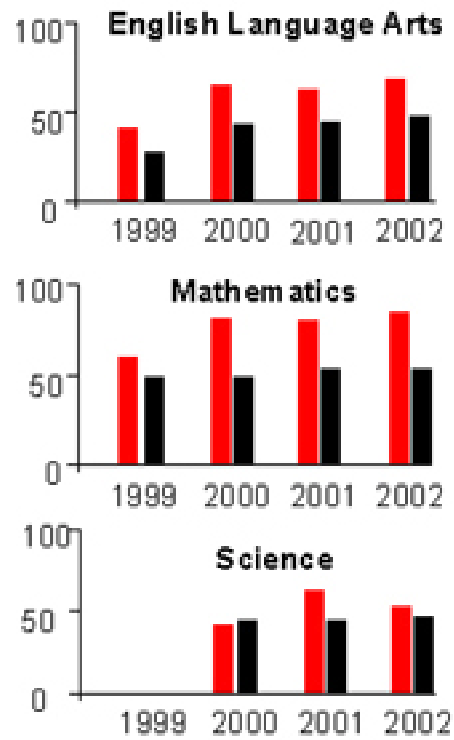

FIG. 1. Percentage of students meeting or exceeding the 4th grade performance standards in English, Language Arts, Mathematics, and Science from 1999 to 2002. No data was available for 1999 science scores. Red columns indicate P.S. 198, and black columns indicate average figures for all New York City elementary schools.

Modules Taught by Scientists

Two new modules have been developed to teach the students of P.S. 198 about cells and microbes: “Cell, the Unit of Life” and “Bacteria are Everywhere**.”** It was noted that the children had already been introduced to these subjects in various ways, and the program ensures that they receive accurate information while experiencing a scientific, experimental approach to the subjects. Focusing on these subjects enabled the children to master new scientific concepts, which created a strong motivational force to continue their learning experience. The modules were taught to two classes of either 4th or 5th grade students. Students gathered in the science laboratory room and were seated in rows. We team taught and involved the students as much as possible. Other scientists from Mount Sinai in the fields of Neuroscience, Evolutionary Biology, and Space Science gave additional input for the modules.

For both modules, we created blackboard-sized posters which showed the basic features of cells and bacteria. To illustrate the differences between living and nonliving things, real plants and facsimiles were passed around. By touching and observing these specimens, the students were able to anchor the information to sensory input. Notions of structure were then introduced. The real plant displays highly intricate and relatively small structures that grow and change to become leaves. A sequence of enlarged microscopic photographs of a meristeme represented a plant tissue in the process of forming a leaf. Through a discussion of the illustrations, the students learned that thousands and millions of units formed the meristeme: cells are the units of life. A second illustration showed a cell from the meristeme that was cropped out and enlarged to demonstrate the ultrastructure of the cell, and the children were able to learn about the basic components of cells. We geared the discussion towards a more generalized concept: “that, as with plants, animal and human tissues are made of cells. In fact, *all* living things are made of cells.”

Once the children had learned about cells and tissues, we explained that cells can also exist alone, as they are the simplest organisms. To introduce bacteria, a large illustration was used as well, but it was made clear to students that microorganisms are not visible to the naked eye. To see microbes, it was necessary to grow them with nutrients, as on a semisolid surface like nutrient agar plates. Under close supervision, each student was given one agar plate that they could either touch or kiss or inoculate with a soil sample taken from the bottom of their sneakers. The plates were incubated at 37°C at Mount Sinai and taken back to the students one week later for evaluation and description with their individual class teachers. Figure 2 shows that the impressive growth observed on plates led to lively class discussions. All agar plates were taken back to Mount Sinai and incinerated. Finally, a short handout with questions was distributed to the students for homework. Performance on the handout showed that the students were not only able to answer the questions correctly but also could provide detailed information when it came to drawing and labeling the parts of a cell. The anecdotal results clearly demonstrate that by introducing students to real science procedures, performed by recognized experts themselves, and involving students in genuine scientific discussions at an early age, we enabled them to master new concepts which provided a motivational engine that greatly enhanced their learning experience.

FIG. 2. Drs. Schlegel (at right in top left panel) and Muñoz-Jordán (bottom right panel) teach 4th and 5th grade students their two newly developed modules, “Bacteria are Everywhere” and “Cells: the Units of Life.” The children are very motivated to observe the ultrastructure of cells in the plant meristeme and the growth of microorganisms on agar plates.

Discussion and Future Directions

Science Week aims to provide students with an array of novel activities delivered by primary science educators and recognized scientists. Students learn to make predictions, conduct experiments, and record their observations while being closely guided by experts in different scientific fields. We learned that it was necessary to assess students' knowledge **before** we teach them so we can modify our objectives and tools in accordance with their age and educational needs.

A short questionnaire was distributed to a group of 4th grade students that had not interacted with us previously. The study showed that approximately 90% of the students had heard the word "cell" and about 65% had heard the word "microbe." However, more had heard the word "anthrax" (40%) than "yeast" (35%) or *E. coli* (19%). More detailed research needs to be done, but we suspect that the students' knowledge stems more from public broadcasting and infotainment rather than basic science education. Strong emphasis has to be given to introducing basic concepts and terms at an early age with easy-to-understand applications and fun-filled hands-on tasks.

Two new modules have been developed to teach the students about cells and microbes: "Cell, the Unit of Life" and "Bacteria are Everywhere." Focusing on these subjects enabled the children to master new scientific concepts, which created a strong motivational force to continue their learning experience.

As a consequence of our interaction with P.S. 198 students, teachers and parents have also become involved in the effort to enhance the science curriculum. Teachers spend more hours teaching science and are interested in acquiring more science books and materials and bringing scientific ideas into the classroom. Parents generously purchased two modern microscopes and a digital camera, allowing direct visualization of microscopic specimens on a computer screen. The interest generated makes us hopeful that P.S. 198 will quickly become a science education model in the New York area.

We have witnessed the transformation of a classroom into a laboratory where young children with accurate, basic instruction can experience the world as scientists. Our advanced teaching modules enable students to make predictions, conduct experiments, and record their observations while being guided by experts in different scientific fields. Currently, two new modules are being designed which will introduce children to DNA and the biology of viruses. We envision that Science Week at P.S. 198 will help to close the gap between science teaching and scientific research and preserve the natural curiosity and enthusiasm of young children.

Acknowledgments

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References

1. **Board of Education of the City of New York.** 1999. Performance standards science. New York City - 1st ed. New Standards, National Center on Education and the Economy and the University of Pittsburgh.

2. **Moreno, N. P., K. A. Chang, B. Z. Tharp, J. P. Denk, J. K. Roberts, P. H. Cutler, and S. Rahmati.** 2001. Teaming up with scientists. Science and Children **39**(1)**:** 42–45.

NEWS AND VIEWS

Service Learning: A Two-Way Street

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According to Pamela and James Toole, "Service-learning is a form of experiential learning where students apply academic knowledge and critical thinking skills to address genuine community needs" (www.dpi.state.wi.us/dpi/dltcl/bbfcsp/sldppage.html). In this broad definition, teachers and students provide a generic service to their community, perhaps by cleaning up a local stream or volunteering at a nursing home. However, in many cases, the service provided is that of teaching younger students. As examples of such programs, the microbiology-based service-learning projects at the University of Minnesota and at Colorado State University were designed so that both the older and the younger students learned from the experience. For most readers of Focus On Microbiology Education (FOME), it is probably obvious that service learning is supposed to be a two-way street, benefiting the person(s) doing the teaching as well as those being taught. However, in my limited experience, interactions between universities and K-12 schools may be more of a one-way street. In a community such as mine, home to a large research-oriented university medical center, it is easy to view service learning as noblesse oblige, an arrangement where the university faculty provide the service so that the public schools in the area can benefit from their expertise. Make no mistake, the benefit is real and very much appreciated. However, from the university side of the fence, we seem to have been focusing more on the "service" than the "learning." As someone who has been both a high school teacher and a university instructor, I think we should remember that **we** have a lot to learn in the process of working with K-12 schools.

First, we should remember that unlike those of us who were educated in the science of microbiology, teachers in the schools we visit have been educated in the science of teaching. While that does not ensure that they are better teachers than someone trained as a scientist, we should admit they may know a thing or two from which we can benefit. For example, some of us teach as if we assume that everybody learns in the same manner we do, even though research shows this is hardly the case. K-12 teachers have studied how people learn, both as individuals and in groups, and perhaps better appreciate that not all of us learn in the same way. As a result, they have likely experimented with different teaching techniques that we may not be familiar with. (Perhaps I am "preaching to the choir" here. I suspect that the people who read FOME are the "exceptions" rather than the "rule" when it comes to a willingness to try creative approaches in teaching microbiology.)

Also, secondary school teachers, unlike many of us at the college level, have had the benefit of significant peer review, likely including videotaping, as they developed their teaching techniques. And hopefully they have refined those techniques while employing them over and over, typically five times a day, 5 days a week, year after year. Again, I realize that many of you who are reading this spend numerous hours in front of a class and are quite creative in your approach. However, in my department which has a strong research orientation, the largest number of lectures given by an individual per year is sixty, while other professors give only two a year, and most give less than a half dozen. In contrast, a high school science teacher may "stand and deliver" a thousand times each year and has not only been the subject of peer review but probably also has observed and critiqued the presentations of others. In recent years I have spent considerable time observing professors and graduate students while they teach and discussing the process with them afterwards. I am grateful for their willingness to listen to my suggestions and equally grateful to my high school teaching colleagues many years ago who gave up their prep periods to watch me. Such peer review, both official and unofficial, is unfortunately less common at the university level.

Teachers in the schools we visit have been educated in the science of teaching. While that does not ensure that they are better teachers than someone trained as a scientist, we should admit they may know a thing or two from which we can benefit.

I believe that our colleagues in the K-12 world have given more thought to **how** kids learn rather than just **what** kids should learn. This is particularly true when you consider the developmental and motivational differences between your average fifteen-year-old and his college counterpart. For example, in our state, all students are required to pass biology in order to graduate from high school. Thus, high school teachers have to develop strategies to accommodate students with a much wider range of abilities and learning styles than the students most of us typically face. I agree that we all struggle to teach and motivate our students, but might we not learn something from the men and women who have had to develop the means to reach those same students and others with even more challenging needs? Might not our students learn from them as well if the collaboration is designed to encourage it?

Aside from the pedagogical skills that K-12 educators have developed, they are likely to have been forced to figure out how to do more with less. Those of us in education at all levels are familiar with tight budgets. However, our public school colleagues have faced deeper cuts for longer periods of time than most of us have. In some cases, the cuts have hampered their efforts. But in many cases, budget cuts have forced teachers to develop some creative approaches; after all "necessity is the mother of invention." One of my most memorable lessons involved teaching anatomy at a cash-strapped community college using disposable chopsticks from the neighborhood Chinese restaurant to dissect donated organs from the local meat packing plant. So who knows? When working with even less than we have now, perhaps some of us might rediscover life beyond PowerPoint presentations.

Perhaps you have never tried a service-learning project in which your students take microbiology into the K-12 world as part of your microbiology course. While I agree it is not the fastest way for your students to acquire microbiology content, they may learn something equally useful. Think back: if you are like many of us, you taught your first microbiology class with precious little teaching experience. Maybe you had assisted in some labs when you were a student. But more likely you just took the existing course outline the last instructor left and jumped in with both feet. In any event, I think you would agree that it would have been helpful to have had some prior teaching experience before starting that full-fledged teaching job. Unfortunately, if you did not get a degree in education, there was little opportunity for such "practice teaching," a period in which you built a lesson from the ground up and then tried it out on someone else's students. If your classroom experiments flopped in this practicum, you learned from the experience without having to wear it around your neck for the rest of the semester. So think of letting your students learn some microbiology while also learning a bit about teaching at the same time, both from you and from the secondary school teacher. They might just decide to follow in your footsteps!

I think it is also fair to assume that for many of us, teaching is only a portion of what we do. Many microbiology faculty wear multiple hats and are under pressure to publish, write more grants, and expand their research. In light of these stresses, time spent teaching becomes more of an obligation, and creativity in the classroom becomes harder to achieve. Yes, this is hardly unique to college teaching, for there are certainly burned-out high school teachers who lack the creative spark; but the vast majority of the ones I was lucky enough to work with taught not just for a paycheck, but because they loved it. Simply put: **teaching** was their focus. Yes, they loved their material, be it science or social studies. But in the process of teaching, they were able to derive energy from the enthusiasm of their young students. Frankly, in my experience it is harder, though certainly still possible, to get that same benefit when working with medical and dental students. These students may appreciate the science even more, but they are older and more goal oriented, and frankly harder to dazzle. When you, and perhaps your students, go to teach in the local high school, you will avail yourself of the chance to turn the younger kids on to microbiology, a subject they have never really thought much about, and see their eyes light up. You may just be reenergized yourself.

As you and your students work with the local science teacher, keep an open mind as well as open eyes and ears. You may well walk away with some useful learning. If nothing else, remember to treat the experience as a two-way street. After all, showing the K-12 teacher that you can learn from them is a simple sign of respect. While they certainly appreciate the expertise you bring into their classrooms, they will also appreciate being treated as a fellow professional.

JOURNAL WATCH

Kathleen S. Jagger
Transylvania University

In this feature for *Focus on Microbiology Education*, journal articles of particular interest to our readers are cited. Two types of articles, those addressing pedagogy or scholarship of teaching and those relating disciplinary content of general interest within microbiology, are included. Please feel free to share your suggestions of interesting articles by contacting me at kjagger@transy.edu.

Pedagogy:
Caccavo, F. et al. 2003. The biological fuel cell. Am. Biol. Teacher **65:**615–618. (An integrative lab activity that incorporates microbiology, chemistry, and physics and could lead to many open-ended projects.)

D'Avanzo, C. 2003. Application of research on learning to college teaching: ecological examples. BioScience **53:**1121–1128. (Reviews impact of metacognition on teaching biology; includes many practical examples.)

Microbiology Content:
Darwin, K. H. et al. 2003. The proteosome of *Mycobacterium tuberculosis* is required for resistance to nitric oxide. Science **302:**1963–1966. (Proteosomes protect *M. tuberculosis* against biochemical stress in its host.)

Edmunds, P. J., and R. D. Gates. 2003. Has coral bleaching delayed our understanding of fundamental aspects of coral dinoflagellate symbioses? BioScience **53:**976–980. (Interesting comparison of several mutualistic symbioses and what drives research on these partnerships.)

Li, W. et al. 2003. Angiotensin converting enzyme 2 is a functional receptor for the SARS coronavirus. Nature **426:**450–454. (This suggests that ACE inhibitors used for treatment of cardiovascular diseases might be explored as therapy for SARS.)

Nettelbeck, D. M., and D. T. Curiel. 2003. Tumor-busting viruses. Sci. Am. **October:**68-75. (A good general article on virotherapy for cancer.)

Tovar, J. et al. 2003. Mitochondrial remnant organelles of *Giardia* function in iron sulfur protein maturation. Nature **426:**172–176. (Evidence that *Giardia* once had mitochondria and still retains a functional organelle, a mitosome, from its endosymbiont. See related news article in same issue p. 127–128.)

WEB WATCH

Indiren Pillay
Southwest Tennessee Comm. College

The Winter 2004 edition of WebWatch focuses, appropriately, on influenza and severe acute respiratory syndrome. If there is a website you have found useful in your learning or teaching, email it to Indiren Pillay at ipillay@southwest.tn.edu and he will share the wealth!

http://www.cdc.gov/ncidod/diseases/flu/index.htm
The Centers for Disease Control and Prevention's "**Flu in the United States**" website is very current with recent summaries of the virus' progression and chapters on the disease, the virus, and current prevention methods. It includes information on the latest vaccines.

http://www.pbs.org/wgbh/amex/influenza
The severity of an influenza epidemic is illustrated at the PBS website showcasing their American Experience episode, "**Influenza 1918.**" This website has some nice resources for the layperson (and the academic) on events of 1918, including a timeline, maps, and personalities. A Teacher's Guide is included.

http://sarsreference.com
In keeping with the respiratory infection theme, **SARS Reference** is a medical textbook that provides a comprehensive and up-to-date overview of severe acute respiratory syndrome (SARS). This text is downloadable free of charge in accordance with the Amedeo Free Book Initiative. Updates are provided as well; the newest edition is from October 2003. The information is available in a number of languages.

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Barbara Millis
Director of Faculty Development, U.S. Air Force Academy

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