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# Full Integration of Undergraduates into Laboratory Research

David A. Atwood

*University of Kentucky*, [datwood@uky.edu](mailto:datwood@uky.edu)

Aaron Hutchison

*University of Kentucky*

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**David Atwood***Professor, Department of Chemistry***Aaron Hutchison***Graduate Student  
(Expects to graduate  
with his Ph.D.  
in December, 2002)*

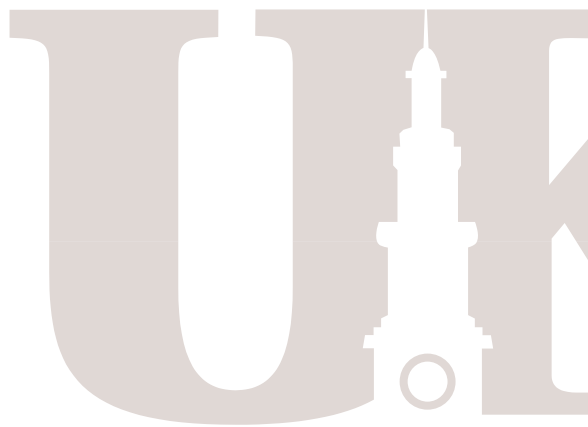
*Mexican undergraduate visitor Eduardo Jimenez in the laboratory with Professor Atwood (Center) and Aaron Hutchison (right).*

## Full Integration of Undergraduates into Laboratory Research

Undergraduate research has always been a high priority in my research group. There are many interrelated reasons for this. Perhaps the simplest is the fact that I myself began my chemistry career by conducting research as an undergraduate at the University of Alabama. After two years of work I had authored two publications and, more importantly, I had experienced first-hand the enjoyment and importance of scientific research. Of course, I had also experienced the many difficulties associated with conducting research but learned that devoted effort, with timely help from others, was all that is needed to move past any obstacles.

Aaron and I and, indeed, my entire research group, now firmly believe that undergraduates should be an integral component of any modern research laboratory and as important as graduate students and postdoctoral associates. Spending time teaching these students allows us to fulfill our mission as an educational institution. Whether or not the students choose to continue their scientific careers, their research efforts will give them the experience to make an informed decision when the time comes. The knowledge they gain from hands-on research cements the concepts they learned during their coursework. Furthermore, their graduate and postdoctoral mentors are a constant resource to help with homework discussions or explanations of difficult concepts. Thus, undergraduate research is a complement, rather than a detriment, to the students' classroom performance.

In turn, the graduate students and postdoctoral associates benefit by learning how to train and work with others. This is something they will have to do well in both industry and



academia to be successful. Also, they gain a deeper knowledge of the concepts they are using because they are forced to teach, rather than simply apply them.

One additional consideration is the fact that our undergraduates are exceptionally talented. What I have found is that it takes a couple of years to provide them with the experience and background necessary to truly understand the research. When they reach this level, however, they make dramatic contributions to our research program. The graduate students and postdoctorals with whom they work are lucky, privileged individuals. Lauren DePue is one such undergraduate student. She began working with graduate student Timothy Keizer two years ago. Her work with Tim has led to two publications, one a communication in one of our discipline's most prestigious periodicals, the *Journal of the American Chemical Society* (124 (2002) 1864). A great deal of Tim's success in his last year as a graduate student (he is now a postdoctoral associate for the Department of Energy in Los Alamos, NM) can be attributed to Lauren's contributions. Her experience is evident in the fact that she is now responsible for training a new graduate student in our group.

Mary Proffitt is another remarkable success story. She began working two years ago with postdoctoral associate Melanie Harvey (who has recently left for a faculty position at the College of Mary in Kansas), and will have numerous publications, beyond a prestigious *Chemical Communications* already in press ((2001) 2094), by the time she graduates after another year or so. In fact, she is now totally independent as a researcher and finishes projects that would be suitable for a postdoctoral associate.

Two other undergraduates who began with me almost three years ago have been independent for some time. Brock Howerton has been working with Matthew Matlock for over three years on environmental metal binding agents. In addition to having well-over eight publications including one each in the American Chemical Society journals, *Industrial and Engineering Chemical Research* (41 (2002) 1579) and *Environmental Science and Technology* (36 (2002) 1636), he is also a co-author on a patent (co-authoring with Matlock and Atwood). He is a clear example of the scope and volume of research that a talented and well-trained undergraduate can accomplish if given sufficient time.

Brandon Conley also began his research nearly three years ago and is now working on projects of his own choosing, in particular the relationship between inorganic sources of fluoride and biological substrates. He has also been a prolific researcher and has shown a talent for writing. His most recent project is a review chapter for the book series *Structure and Bonding* entitled: "Fluoroaluminate Chemistry" (to be published in the Fall of 2002).

One thing that these four highly successful students have in common is that they began research early in their careers here at UK, before

or during their sophomore years. There is growing consensus among chemical educators on the need to expose undergraduate students to research early (N. Craig, *Journal of Chemical Education* 76 (1999) 595). What we have recognized is that, despite the students' ingenuousness at this stage, there is a tremendous advantage to having them trained, in an unhurried fashion, over the course of several years. What the students do not have in textbook knowledge at this point (although their GPAs are generally higher than 3.8), they make up for in creativity and curiosity. In a recent article in the *Journal of Chemical Education* (A. R. Hutchison, D. A. Atwood 79 (2002) 125), we outlined how such an "early start" program works. Key features to the successful integration of undergraduates at such an early age are the commitment of all members of the hosting group, as well as clearly established plans for projects and training.

In the past year, we have begun expanding our undergraduate research approach to include high school students as well as international undergraduates. One such participant is Joe Swisher, a remarkably talented student whose work in our laboratory is facilitated by the Math Science and Technology Center at Paul Laurence Dunbar High School. Joe is working with Matlock and Brock and contributing substantially to a great deal of soon-to-be published research.

International visitors include Eduardo Jimenez (shown in the photograph to the left of the authors) and Miguel Viveros from Mexico, and Maxime Siegler from France. These students are part of a National Science Foundation, Research Experiences for Undergraduates program, with contributed funding from departmental resources and individual grants. The UK-EPSCoR program is also responsible for two students and a faculty member who are visiting for the summer. In all, there are nearly 30 undergraduates in the chemistry department this summer and close to ten on-site year-round.