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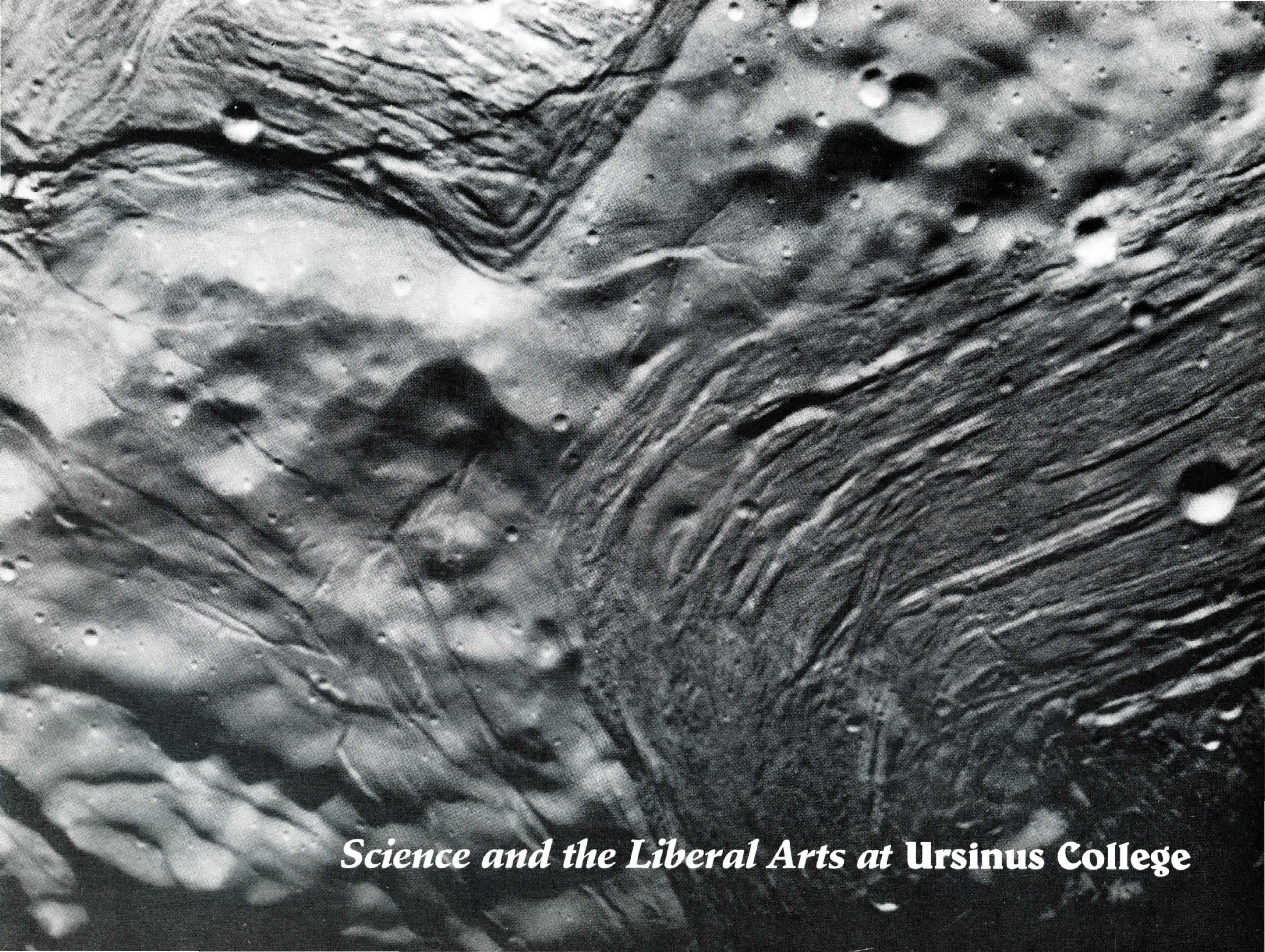
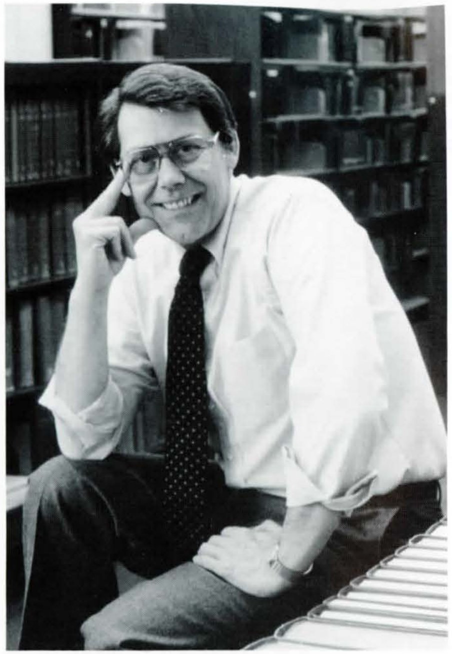


Science and the Liberal Arts at Ursinus College

The following articles are from presentations made on Founders' Day, November, 1985, on "An Exploration of the Role of Science in the Liberal Arts." Also included are a number of other articles written by alumni scientists and by members of the College administration. The cover depicts the terrain of Miranda, a moon of Uranus, as photographed last January by the Voyager 2 space probe. The picture is used through the courtesy of the Jet Propulsion Laboratory, Pasadena, Calif., which manages the Voyager project for NASA.

Science Trend: Moving Beyond Industrialism

By Dean William E. Akin


Bill Denison

William Akin

In the past 30 years, we have become increasingly aware that the American economy, and with it American society, is entering a new era. We have been in an age of transition to a new period of history, moving toward a society whose shape and form are, at this time, unfocused. Our society may yet turn out to be a "brave new world" or a "great society."

Despite our inability to see the future precisely, it is apparent that the U.S. is leading Western Europe, Canada and Japan into a "post-industrial" state, where economic well-being will be less dependent on the production of heavy industrial products and durable consumer goods, and more dependent on the products of high technology, and on services.

In the post-industrial world, the nation's future well-being will in no small way be dependent on its ability to maintain leadership in basic science and high-tech applications (which grow out of scientific understanding) while keeping sight of the need to enrich the human condition.

In the 1980's we have reason to be concerned about our success in producing the next generation of top-quality scientists. We have heard much in recent years about the crisis in high school science and mathematics. At an alarming rate, college science and math majors are rejecting careers in high school teaching, and to a lesser extent college and university teaching, for higher-paying positions in industry. If we eat our "science seeds" now, how will we raise our future crops in science and mathematics?

As serious as this trend is, it masks an even more serious trend: Fewer high school graduates are opting for careers in the sciences; in the mid-80's, only about one-half as many freshmen intended to major in the sciences as did in the mid-70's. Not surprisingly, the number of baccalaureate degrees and graduate degrees in the basic sciences has also plummeted.

Set against the alarming national trend away from the sciences, selective liberal arts colleges—including Ursinus—have reason to be quietly proud of their accomplishments. As a group, they continue to attract a high percentage of students interested in science, well above the national average. At Ursinus, the number and percentage of freshmen who declare a science interest has not changed significantly over the past decade. Such colleges have traditionally graduated a disproportionate number of science majors who go on to graduate and professional schools, and this continues to characterize science programs at the selective liberal arts colleges. Clearly, the best liberal arts colleges are doing something right.

In an effort to spotlight the success in science education of the quality liberal arts colleges, and to examine the factors contributing to that success, Oberlin College last summer produced a major study on *The Future of Science at Liberal Arts Colleges*. The study documented the importance of the leading liberal arts colleges in the preparation of America's scientists. Such colleges have maintained or increased their number of science graduates, and continue to send a higher percentage of their graduates onto doctoral and professorial degrees, than do other types of colleges. In attempting to explain the reasons behind this achievement, the report asserted that "*personalized instruction* by senior scientists and widespread *student involvement in research* are the primary distinguishing features of these institutions, and account for their record in both attracting and producing young scientists." [Emphasis added.]

The Oberlin Report provided the occasion for many liberal arts colleges to reexamine their science programs. Ursinus has a longstanding commitment to science education in a liberal arts context. As Roger P. Staiger, chairman of our chemistry department, has reminded us, the initial appointments of Ursinus' first president, J.H.A. Bomberger, included Dr. J.W. Sunderland as professor of chemistry, geology and botany.

"Ursinus College stands on the threshold of a new quantum jump in science education. We are ready for a higher energy level of participation in the educational world of science in a liberal arts program."—Dr. Roger P. Staiger

"I know that our students are responsible for the joy that comes from teaching. We at Ursinus are most fortunate with respect to the quality of our student body."—Blanche B. Schultz

The College has reason to take pride in its science students and science graduates. Retiring professor of mathematics Blanche Schultz speaks for the entire faculty: "I know that our students are responsible for the joy that comes from teaching. We at Ursinus are most fortunate with respect to the quality of our student body. We encourage and commend those who extend themselves beyond what is expected."

But the College also looks forward to addressing the challenges and needs of science education in the post-industrial world community. Dr. Staiger, who holds the David Laucks Hain Chair in Chemistry, expressed the College's opportunity and commitment last Founders' Day when he said: "Ursinus College stands on the threshold of a new quantum jump in science education. We are ready for a higher-energy level of participation in the educational world of science in a liberal arts program."

If we are to meet the challenge of science education and to move to realize "a new quantum jump in science education," we need to understand with greater clarity why small liberal arts colleges in general, and Ursinus College in particular, have had the success they have in educating scientists. What factors have contributed to that success? Only with that understanding can we build for the future.

While the Oberlin Report postulated answers in its emphasis on "one-on-one teaching by senior scientists" and "student involvement in research," it did not offer compelling evidence to support a conclusion that those were the sole characteristics which accounted for the record of quality liberal arts colleges in attracting and graduating scientists. Nor is it clear, that even if generally valid, Oberlin's answers hold for particular colleges.

Ursinus attempted to address these concerns, in part, by inviting back to campus last Nov. 2, Founders' Day, several graduates in biology, physics, and chemistry who have gone on to doctorates and academic careers in science. They spoke at a special science symposium entitled "An Exploration of the Role of Science in the Liberal Arts College." The fundamental question they examined had to do with their experience at Ursinus: what was it about this campus which most contributed to their transformations from timid freshmen into successful scientists?

In the pages that follow, the Founders' Day presentations of these four, and President David Ellis of Lafayette College, are printed in their entirety. In addition, several other outstanding alumni scientists have contributed articles, and Debra Kamens, director of communications, reports on the Montgomery County science fair, held each year at Ursinus. The articles by alumni reflect on their Ursinus experiences, which are as varied as their times and their personalities. But there are also common threads: an emphasis on the small size and the contributions of a friendly environment; a faculty mentor or model who served as an important intellectual catalyst. In every case, the liberal education provided them with a broad perspective on the world, and promoted the art of critical thinking and writing. Confidence, creativity, flexibility, logical thought, emerge as keys to their sense of success, not just as scientists, but as individuals concerned with creating a better world.

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This special publication is dedicated to all of those Ursinus scientists, past and present, who have spent their careers in the laboratory, the field, in industry, the military and the government, in search of new answers, new solutions and new understanding.

Small Colleges Nurture Young Scientists Well

By Dr. David W. Ellis
President, Lafayette College
Founders' Day, 1985

This is an important day for Ursinus College, as you focus on the role of science in the liberal arts college.

I am very pleased to have been asked to speak on this occasion. As a scientist who was educated in a liberal arts college, and who taught, did research and served as a university faculty member, and who now serves as a college administrator, I believe very deeply in the liberal arts tradition and in the role of science within that tradition. It is all too easy in this day and age to overspecialize, but we have ample studies to show that those who are broadly educated carry distinct advantages for a productive life that will extend 50 or 60 years after the normal college experience.

There are some who think of the liberal arts as excluding the sciences; I am not among them. Science has been studied as long as there has been recorded history and even before. Natural philosophy was taught for centuries and formed the basis for what we call physics today. Mathematics in its various forms has been a subject of study since the Sumarians. Science is indeed an integral part of the liberal arts.

The scientific revolution from roughly 1550 to 1700, with which we associate such great names of science as Copernicus, Bacon, Harvey, DesCartes, Galileo, Newton and others, was part of an era of intellectual ferment in many disciplines. It was the time of Michelangelo, Shakespeare, and Monteverdi, as well. Those great steps in science which started us down the paths we still walk today occurred in the context of the Enlightenment, the Protestant Reformation and the increasing secularization of educational institutions.

What is this science I am talking about? Many textbooks define it as the study of the world in which we live, including the universe and space: they speak of the scientific method and of cause and effect; they note that scientists tend to work with systems that are quite reproducible, particularly in comparison to the systems with which social scientists must work. But what intrigues me is the rapid development of virtually all of our basic sciences over the last two or three centuries. The big bang and equilibrium theories have raised new questions of a fundamental order in astronomy. Plate techtonics has revolutionized geology. The application of what used to be thought of as the most impractical and theoretical sort of mathematics has become almost commonplace. Biology has moved from classification and the simple understanding of physiological phenomena, to a myriad of sub-specialties and innumerable applications to agriculture, environmental protection, health and many more.

As I look back at chemistry, my own discipline, it is phenomenal to see what has evolved. It was only 211 years ago that LeVoisier first postulated the principles of combustion. This is frequently described as the beginning of the science of chemistry. There followed rapidly the laws of conservation of matter and energy, the law of defined composition, Dalton's atomic theory, the periodic table, atomic structure and radioactivity. Less than 100 years ago the existence of electrons was discovered, as were the nucleus, protons and neutrons; the Bohr atom was postulated. Less than 50 years ago, the so-called inert gases were found not to be inert under all conditions, and theories of bonding have expanded greatly. So within a period of 50 to 100 years, and at the most 200 years, there has been dramatic growth in this one area of science. The same can be said for other areas of science as well.

But it is important to stress that the boundaries of disciplines themselves are no longer easily defined. The disciplines bump up against each other, and whether it is the *Journal of Chemical Physics*, or the *Journal of Physical Chemistry*, there are many areas where people work to understand systems, develop theories, classify data, test theories, and postulate new theories, both within the disciplines and on the margins between the disciplines. Just think for a moment what is at the margin: for example, biophysics, biochemistry bioengineering, genetics, and now more recently that most intriguing and challenging area: neuroscience.

Let me return now to the fundamental point of our discussion today—science in the liberal arts college. What is the key to all we have been talking about in science? The answer is well-educated people! There is no substitute for the people who have the ideas, form the postulates, perform the experiments, and carry through to try new experiments time and time again.

Naturally, when we talk about the well-educated young person, we are talking about the very mission of colleges like Ursinus, The mission is not just to educate the student in an individual discipline or just for a first job; it is to create educated human beings prepared to contribute to the world in which they will live throughout a long productive life.

How do liberal arts colleges best approach the goal of producing well-educated young people who are highly motivated to take their proper place in our society? I believe the answer involves bringing young students of ability, who are willing to work and motivated to learn into contact with dedicated faculty in an environment where together they explore and learn. That principle works whether in science or in other disciplines. That principle, I believe, works best in residential liberal arts colleges like Ursinus and Lafayette and many others.

During 1984-85, 48 colleges which had good records of graduates going on for doctoral degrees and receiving N.S.F. [National Science Foundation] fellowships, high quality students and professionally active faculties, were selected for an in-depth study centered at Oberlin College. I am going to be talking briefly about those 48, because the data developed for them is by far the best data available concerning science in liberal arts colleges.

Briefly the study shows that at a time when freshmen students in higher education as a whole have evidenced a declining interest in science (a decline of 33 percent from 1976 to 1984), freshmen in those 48 institutions have maintained a strong interest in science, with only a modest decline (12 percent). What about the graduates? Nationally in 1975, 9.4 percent of the bachelor's degrees were awarded in the basic sciences. That had declined by 1983 to 7.5 percent. In the liberal arts colleges studied, however, the figure remained nearly constant, with 24 percent of the students graduating in science; that percentage is more than three times the national percentage and nearly double that found in the leading research universities of our country. In fact liberal arts colleges are key feeder schools for students going on to graduate study, in all fields. If one looks at the number of Ph.D.s conferred, more of the graduates from the institutions studied go on for doctoral work than do graduates from any other group of institutions including the major research universities and the Ivy League. Also, and I think very important, our liberal arts colleges have brought many more women into the study of science.

Another area studied was the research productivity of the faculty in the 48 colleges. Sixty percent of the faculty had averaged one article per year in each of the prior five years and 30 percent of the articles were jointly authored by students and faculty.

What is it that makes these liberal arts colleges so distinctive and so productive? After all, other institutions have dedicated, caring, intellectually involved, scholarly faculty members and inquisitive, intelligent, motivated, even driving students. The answer has several parts. First is the personalized interaction between the student and experienced faculty members. Second is genuine sharing in the learning, both in class and in laboratory. Third is active participation by students and faculty in research. To put it differently, it is the joint endeavor of exploration in teaching, learning and research which accounts for these institutions' records in both attracting and producing young scientists of note. I feel confident those same factors apply here at Ursinus just as they did at the institutions studied and at many other colleges as well.

Now, what is that joint endeavor really? What is it from the standpoint of the faculty member and what is it from the standpoint of the student? Those of you who attended the symposium earlier this afternoon heard four distinguished alumni stress the importance of discovery, exposure to the world beyond the college, the opportunity to take a leadership position, the development of confidence, the emphasis on critical thinking and the interrelatedness of disciplines. But through it all, the key point was that interaction between faculty and students is crucial.

Science needs your support. Our country is falling woefully behind the rest of the world in its production of scientists and engineers. That can only bode ill in the time ahead as the world becomes increasingly dependent upon high technology, and the economy becomes more global in character. We must improve basic math and science education in the elementary and secondary schools as well as in the colleges. In addition, colleges and universities are falling behind in terms of modern equipment and facilities. Almost 30 years ago, the Federal government provided substantial funds in response to Sputnik, but equipment bought with those grants is now grossly out of date or inoperative in most instances. Large infusions of funds will be needed to bring science education back to a state of currency. Providing those funds serves a national purpose as well as an institutional one, and is an appropriate Federal expenditure.

In closing, I would like to share two thoughts concerning the liberal arts, and particularly the role of science in the liberal arts. First, the sciences have been perceived too long as separate from the humanities, the arts and the social sciences. In my view, the general educational requirements of liberal arts colleges need to be reviewed and rethought carefully. Content alone is not enough. What students will need to function effectively in the 21st century involves a wide range of skills, as well as content. Just including more science in the curriculum is not enough. What is needed is a more integrated curriculum, which consciously includes areas such as critical thinking, an explicit concern for values, the ability to communicate well and perhaps most important, experience in helping students see important issues in terms of the many factors which might contribute to a better understanding of them and their resolution.

Second, it was only about 100 years ago that modern science became a part of college and school curricula, because it could no longer be ignored. The same is happening today with technology, applied mathematics and computers. People today cannot live in our world and be effective citizens if they do not have some understanding of these things. For this reason, the Sloan Foundation started a program several years ago, of which Lafayette is pleased to be a part, to bring into the curriculum "the new liberal arts"—technology and applied mathematics. The needs of our society demand a broader definition of the liberal arts, one which includes these areas which are so integral, not just to our lives today, but for the lives of our students in the time ahead.

David W. Ellis is president of Lafayette College. A prolific scholar, he has published works in the fields of chemistry and higher education.

Physics Mentor Changed a Life

By Dr. John DeWire, '38

You have asked me to describe the role that Ursinus played in developing my career in science and to suggest how Ursinus, a small liberal arts college, can compete with the large research-oriented universities as a source of future scientists.

It is easy for me to respond to your first request. Ursinus played the crucial role in my becoming a physicist. Recently I was thinking about that rainy September day in 1934 when I first came to Ursinus. Professor Foster Dennis offered me a ride in his Ford Model A convertible, and I gladly accepted his offer. There we were, making our way through the coal region, doing what we could to cope with a leak in the roof of the car. By the time we arrived in Collegeville, we were both rather uncomfortable. My discomfort was not confined to my physical state. I was coming to college, a source of real joy for me, but I had not found a clear purpose for coming here. My only contacts with college graduates had been my teachers, most of whom I admired for their commitments to their difficult tasks. Almost by default, I decided that I would follow their paths and perhaps one day return to teach at Milton High School. I was pleased by the prospect but a bit uneasy that no deliberate choice had been involved in determining the course of action.

All this changed dramatically in my sophomore year when I met Professor John Mauchly, the then Ursinus physics professor, who later achieved fame for creating the world's first electronic digital computer. John was a truly remarkable person whose brilliance became immediately apparent to anyone who approached him, and whose enthusiasm infected each of the students who came into his little world at the south end of the first two floors of the Science Building. In no time I found myself working on one of his many projects, and I was hooked.

I hope you will not misunderstand me when I say that the study of physics in undergraduate school can be tedious and sometimes dull. It is not exactly easy to learn and master the material, and while one is struggling with the concepts, one is always aware that most of the knowledge comes from the 18th and 19th centuries and has been worked over by many in the past. Unless your interest lies in the history of physics, you are not likely to be turned on by such well-formulated concepts, beautiful as they may be. It is the awareness of the present frontiers of physics that attracts today's students to the field.

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Professor Mauchly gave his students two means of developing an interest in physics as a career, one in the laboratory and one outside. In the lab he had many projects going on in addition to the regular classwork. He was interested in molecular spectra and was calculating the internal motions of typical molecules. He taught me a numerical method for solving the high order equations that came from his calculations and put me to work on an antique desk calculator to find the solutions. I have to admit that several hours on that old Marchant could become rather boring, but there were other experiments to attract us. We had a Geiger counter with which we could observe cosmic rays and radioactivity. Mauchly also worked on various weather problems. This work and the molecular calculations were crying out for more powerful computational methods and from the time that I first knew him, he was thinking about better ways than those desk calculators to handle massive collections of numerical data. Before I left Ursinus he had other students wiring simple circuits to do arithmetic. I remember doing one myself.

I believe that Mauchly's activities outside the lab may have had a greater influence on my future than the work in the lab. There was (and I presume still is) an extensive program of physics colloquia and seminars in the Philadelphia area. Mauchly attended nearly all of them and invited and encouraged students to go with him. I attended a number of elegant evening colloquia at the Franklin Institute, at one of which Hans Bethe, whom I have been privileged to call a colleague for the past 40 years, gave some of his early ideas about the structure of the atomic nucleus. One night at Swarthmore, Vladamir Zworykin demonstrated his television camera. One afternoon at Penn, John Dunning of Columbia showed us how artificial radioactivity could be induced by a source of neutrons. That phenomenon had been discovered in France only three years earlier. I didn't understand everything I heard, but I liked what I understood.

Trips to colloquia were not the only items on Mauchly's agenda. He liked to visit laboratories to keep in touch with what was going on in them. He made regular visits to the major laboratories in Philadelphia, Baltimore, and Washington, and again he invited students to join him. I had moved to Baltimore where John would pick me up whenever he was in that area. We visited the Johnson Biophysics Foundation, the National Bureau of Standards, the Naval Research Lab, the Carnegie Institution, and Johns Hopkins University and Hospital. John introduced me to a number of well known scientists, who had previously been only names in current textbooks.

Why were these activities important? I have learned the answers through my experience at Cornell. At a large research-oriented university, undergraduates must work hard to avoid being aware of the research going on around them. In our lab we have many undergrads working on all kinds of tasks, some for course credit, others for pay During some summers, we have had more than 40 students on our payroll. We do not hire them solely to help them. Students are ideal employees. They learn quickly, they have lots of energy, and they can ask embarrassing questions, sometimes helping us to avoid disastrous mistakes. I can cite many examples of students who found their futures in the work they did for us. On the other hand, I have watched students develop a real distaste for a certain area of research at a time early enough in their schooling to enable them to change their programs. In either case, the early work experience has been of great value.

One might conclude that the small college is at a serious disadvantage by not having the large research component at hand. I do not believe this is so. The small college provides an atmosphere in which teacher and student can form a personal relationship that in general only exists at the graduate level in the larger institutions. Within this relationship the teacher can find many ways to guide and encourage a promising student in the search for a way to put his or her talent to work. By describing my own experience, I have covered only a few of the many approaches

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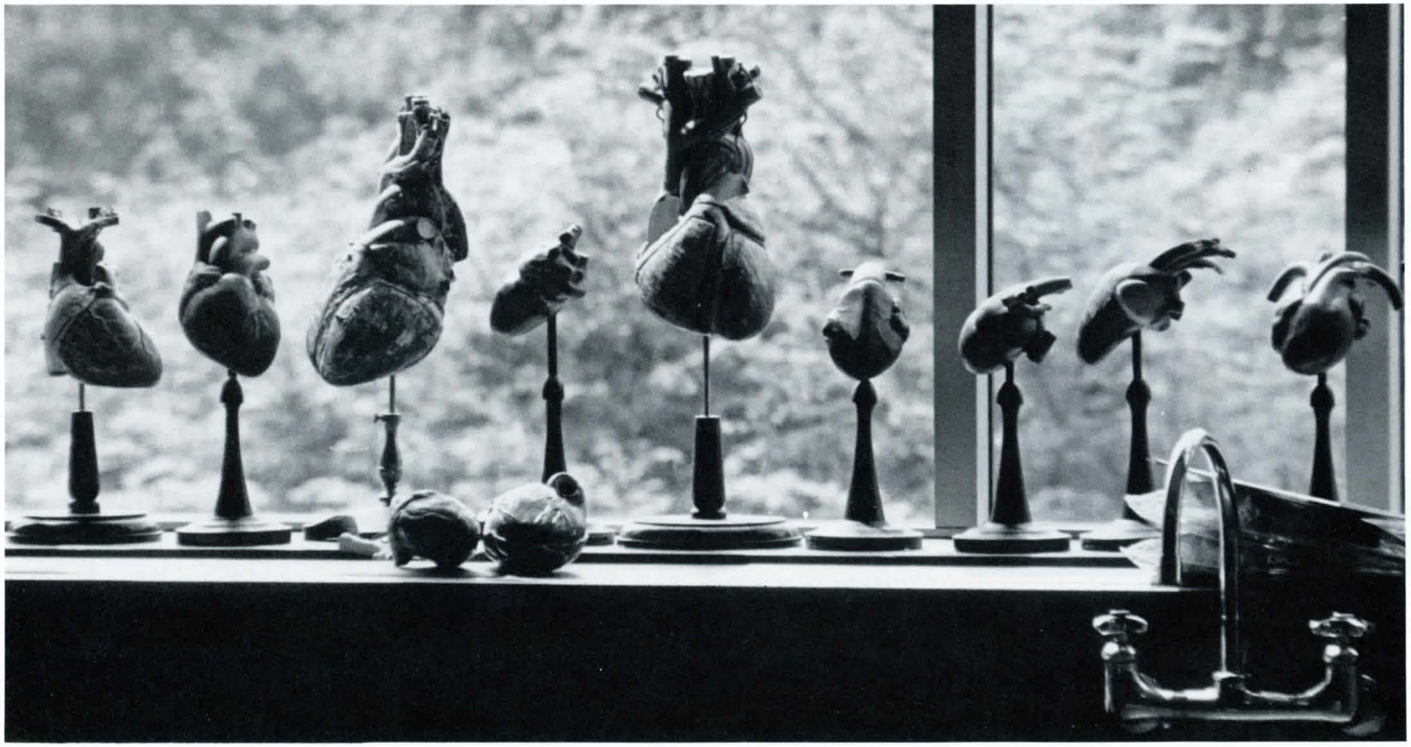
that a teacher can use to enrich a student's horizon. Participation in independent projects in the laboratory or library, membership in a national undergraduate society, taking part in a local student club, all these are components of a program that can direct a student towards a rewarding career.

The small college plays another role that is very important. At the time of graduation from secondary school, students represent a broad spectrum of sophistication, self-confidence, and initiative, quite apart from their intellectual prowess. The atmosphere at a large cosmopolitan university may be just right for some students but entirely wrong for others. The most attractive feature of our national system of higher education is its diversity. It is not at all clear that scientists who in the past came through the small colleges would have been so successful by going to a large university for their undergraduate work. We need both institutions if we are to continue to strive for the ideal society to which all of us can make the most effective contributions possible.

My fellow alumni here on the platform and many others whose accomplishments have been described in the Alumni magazine provide proof that Ursinus has been doing well in the past. But I am sure that we who love and serve this institution all agree that we can and will do better in the future to contribute educated young men and women to fill the roles of leadership in all segments of our society.

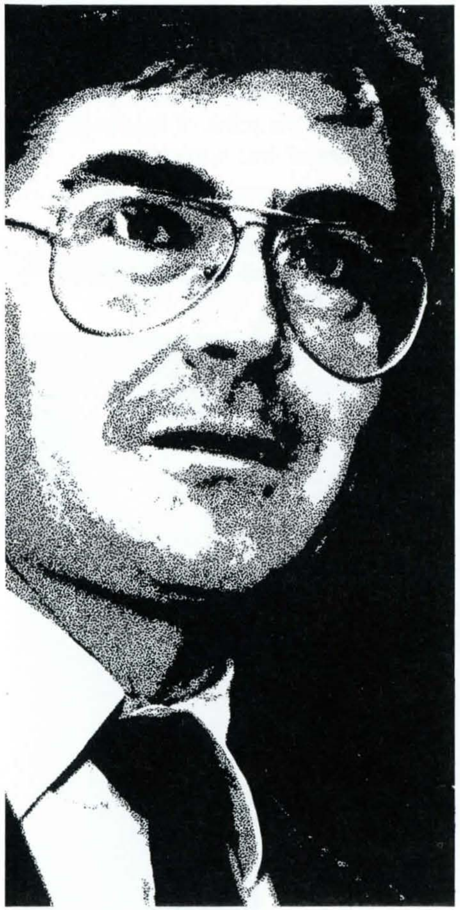
Dr. John DeWire is professor of physics and associate director of the Laboratory of Nuclear Studies at Cornell University. At Princeton and at Los Alamos in the 1940's, he worked on research leading up to the Manhattan Project.

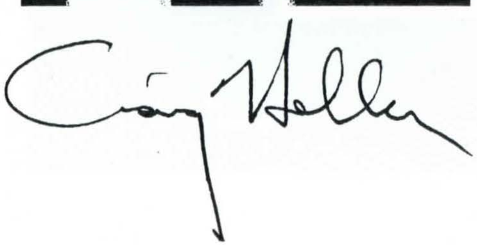


Rick Miller

Complex World A Challenge For Scientists

By Dr. H. Craig Heller, '65





I have been asked to comment on the influences that my undergraduate education at Ursinus had on the development of my post-graduate education and subsequent career in science. Obviously, it is inevitable that one's undergraduate experience will have numerous, diverse, and indelible influences on his or her intellectual and professional life. Time and space are limited, so I shall only mention a few of the most important, which for me were the impressions made on me by individual faculty.

I would like to pay special tribute to a few of those individuals. In freshman English, Lloyd Jones taught me to write effectively. No lesson I learned at U.C. has been of more lasting value over the years. Lloyd Jones also taught another valuable lesson—almost perfect is not good enough.

Another powerful influence on my life at Ursinus also had nothing to do with science. It was the impact upon me of my German professor, Allan Lake Rice. He let me know that there was a world out there beyond Ursinus College, beyond Collegeville, beyond Pennsylvania. The awareness that he created in me of other cultures, other peoples, world events and world problems has been with me ever since.

The person that had the greatest influence on my development is a scientist, Professor Levie van Dam. Dr. van Dam, through his rigorous Socratic teaching, made me realize that minds could be used for activities other than memorizing, and that we could enjoy thinking new ideas, and discovering new information.

During my last years of high school, while I was deciding where to go as an undergraduate, I intended to become a geologist. Ursinus had a very powerful impact on my career choices by giving me a scholarship and not having a geology department. Since I was disappointed in my quest for geology, I followed the most well-trodden path in the sciences at Ursinus College: the pre-med program. I even became president of the pre-med society. At that time, one of the very useful opportunities that was made available to us pre-med students at Ursinus was a chance to visit some of the medical schools to which we were applying. When I did that, I decided that the education offered there wasn't the kind of education that was going to challenge my mind the way Dr. van Dam had taught me to challenge it. I gave up the idea of going to medical school and instead applied to graduate school, where I took the path most opposite from the one I took at Ursinus, and became an ecologist.

Ultimately, I didn't stay on that path either. Since leaving graduate school I have become increasingly more and more a physiologist interested in how the nervous system controls the functions of the body. My advice to students is to pursue what interests you, and do the best you can. The most powerful guidance you can receive comes from being aware of what stimulates you and excites you the most.

I think it would be very difficult for citizens today to survive without some knowledge of science, and the more the better.

I would like to turn the question that's been posed today around a little bit. I think in our contemporary society—whose major hallmark is advances in scientific and technological progress, bringing with it all that implies, from programmable dishwashers to Star Wars—it is not necessary to defend the role of science in a liberal arts education. As a matter of fact, I think it would be very difficult for citizens today to survive without some knowledge of science, and the more the better. So it is very appropriate in a liberal arts education to emphasize an introduction to science, even for the non-scientists.

What we haven't appreciated enough in our quest for developing the best possible science education, is the role that the liberal arts should play in a scientific education. This is an area where small liberal arts colleges can stand to innovate, and far surpass the quality of undergraduate education that exists in many large research universities which are primarily organized along disciplinary lines.

In our society today, we put great emphasis on the value of scientific and technological progress, and we reap the short-term benefits. When we look at the rest of the world, where scientific and technological progress is not the hallmark of society, we say, "well, if we only had the opportunity to apply our technological knowledge, we could change things there, we could put them on the right track."

That is a very simplistic viewpoint. Even in our own society we ignore the social and ethical dimensions of our own progress. We can't worry about acid rain if we need power. VCR's are wonderful, but we don't bother to ask about their possible influence on family structure and child development. We're just beginning to get concerned about events in South Africa. But, where in a liberal arts college in this country do we see in the Western culture program any allusion to the legacy of colonialism? Where do we see any analysis of the fact that we do business in countries like South Africa because the economic structure in a colonial country is conductive to progress and profit in business?

We tend to think that all of the problems in the world, whether they're our problems or other peoples' problems, are amenable to technological fixes, or to slight readjustments of the economic or political system. These are simplistic world views.

We put great emphasis and great value on what science and technology can bring us, and we give little attention to the ethical and social consequences of many of those activities. We tend to think that all of the problems in the world, whether they're our problems or other peoples' problems, are amenable to technological fixes, or to slight readjustments of the economic or political system. These are simplistic world views. Simplistic world views have been dangerous in the past; are increasingly dangerous today, and in the future, could be disastrous.

Problems faced by humans, problems created by humans, are problems which have roots not only in the sciences, but also in social and cultural factors. Probably the most obvious example is the population problem, which differs depending where you are in the world. We tend to say that in this country and Western Europe we don't have population problems. But believe me, we do.

If you were to represent the number of people in each age class by a disk, and stacked the disks one on top of another so that the youngest were on the bottom and the oldest on the top, you would see that the population structures for our country and for Western European countries are columns. There's an equal distribution of individuals in all the age classes. If you did that for the past couple of decades, and made predictions into the future, you'd find that our population column is tending to bulge a little bit at the top. We're becoming a geriatric society. That says a lot about our technological progress. We have made tremendous advances in preventive medicine, in diagnostics, in intensive care, organ transplantation, and so forth. But these bring with them a lot of problems the technologists and the scientists haven't thought about.

What about the ethics of who determines when someone lives or when someone dies? What about the economic decisions of whether to invest a hospital's money in new technology associated with intensive care, or in pediatric nurseries, or in preventative medicine? We can't always have it all. What about the question of organ transplants? Let's say we're successful tomorrow in overcoming the rejection reaction. Are we ready to deal with the black markets that would be created for organs? These types of questions are mind-boggling, but we must deal with them.

Let's look at the other end of the spectrum—the third world. We stack up the population disks again. Now we find that the population structure is very different; it's a pyramid, big at the bottom. Most of the population is *not yet* in the child-bearing years. We thought we had a population bomb 20 years ago. We have an enormous population bomb in these parts of the world today. These are pediatric societies, and they obviously create very different problems from our own.

But don't worry. We have technological fixes. We're going to sprinkle birth control pills from airplanes, and we're going to give these people the ability to control their population. Will they use the birth control pills? You better believe they won't. They want those children. In those countries where they don't have to give children dirt bikes and ghetto blasters, a child is cheap. It's good labor and it's your investment in a retirement plan in a society where there is no Social Security. The population problem has major roots in cultural, social, and economic aspects of those societies, and not in a lack of technology.

To deal with such complex problems in an increasingly complex world, we must produce broadly-trained scholars, and this is where there is great opportunity for innovation in small liberal arts colleges. There is more flexibility in the small liberal arts schools to find new ways to provide integrated education so that young people, before they begin emphasizing career choices and following paths toward a narrow specialization, become capable of looking at problems in a multi-dimensional fashion.

In those countries where they don't have to give children dirt bikes and ghetto blasters, a child is cheap. It's good labor and it's your investment in a retirement plan in a society where there is no Social Security.

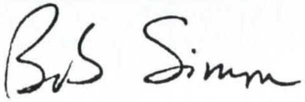
How can this be achieved? We can begin by bringing together the faculties in social sciences and natural sciences, and providing curricula which are integrated; curricula which switch back and forth between the two, and constantly show the student how one relates to another. If your classes in biomedical subjects are not well-integrated with the philosophy department's ethics course, you have room for innovation. If your courses in the physical sciences and molecular biology are not related and integrated with concerns in economics, you have room for innovation. If your courses in evolution are not related to cultural anthropology, there is room for innovation. If links are not made between environmental sciences and courses in political science, opportunities exist for innovation.

Clearly we can produce students with a strong foundation in science who will do extremely well in graduate school. But we should be doing more. Rather than just producing good candidates for "yuppiedom"; we can influence bright, talented young people to develop into responsible world citizens, who will hopefully make a difference in this complex world of ours.

Dr. Heller is professor of biological studies at Stanford University, Chairman of the Program in Human Biology and a leading researcher in the field.

In Government Chemist Finds His Niche

By Dr. Robert M. Simon, '77



I'd like to make three points about how Ursinus College affected my career development and my decision to become a scientist. The first point is probably best introduced with a story about my first day in graduate school.

I was sitting in Room 6-123 at MIT, along with the other first-year inorganic chemistry graduate students, waiting for the professor to appear. We started introducing ourselves and trading names of our undergraduate schools. The girl next to me said, "I went to Columbia University;" the girl in front of me, Princeton University; the guy in back of me, Cal Tech; the person across the aisle, Stanford University. They turned to me and said. "Where are you from?" I looked them straight in the eye and replied, "Oh, I did my undergraduate work at Ursinus College." They looked at me with puzzled expressions for a moment, thinking, are we supposed to know the name of that school?

Despite the fact that I didn't come from a school everyone had heard of, I quickly discovered that I had received a very good foundation here at Ursinus in my chemistry course work. I think that one of the great strengths of the Ursinus chemistry program is that the professors have a gift for communicating the essence of the subject; for giving you an in-depth perspective as to what the key issues in science are. So, when I arrived at MIT, I didn't feel a deficit in terms of my academic training.

Point number two is not so congratulatory. When I arrived in the laboratory at MIT, I did notice a difference between me and the students who had gone to the big-name schools: they were simply much more comfortable with advanced instrumentation than I was. They knew which knobs to twiddle and which dials to read. It took me considerable time and effort to catch up to them. My lack of exposure to modern experimental apparatus and instrumentation was a significant deficit in my training at Ursinus. I am happy to learn that the College is working on this problem very seriously; in the next year or so, they are going to spend approximately $125,000 on instrumentation in the chemistry department alone. If Ursinus wants to be in the game of preparing students for graduate school in the experimental sciences, advanced instrumentation and equipment is a critical investment that absolutely has to be made.

When I arrived at MIT, I didn't feel a deficit in terms of my academic training . . . (but) my lack of exposure to modern experimental apparatus and instrumentation was a significant deficit . . . I am happy to learn that the College is working on this problem.

Purchasing advanced instrumentation carries with it an important hidden cost that I hope the College faces up front—maintenance. Expensive instrumentation breaks. It broke at MIT all the time and it will break at Ursinus as well. There has to be an ongoing commitment from the institution to maintain its instrumentation and to keep it working. You can't learn much from a broken NMR spectrometer.

My third point concerns my ultimate choice of careers and something that Ursinus gave me that had nothing to do with any of the classes I took.

I arrived at Ursinus at a very troubled time in the College's history. It was in the mid-70's (the Sixties arrived at the College about 15 years late.) At that time, the rules for student life were just incredible. For example, women had to be in their dormitories by midnight. They could miss this curfew by a total of 15 cumulative minutes, the infamous 15 "mercy minutes," per semester. For the 1970's, that was a very unusual way to treat young adults.

At the time that Ursinus was struggling with outdated conceptions of student life, it had in place a number of administrators who were not perceptive to the need for change, update, and reform. I had a very interesting time as one of many students who were "stirring the pot," trying to change things.

The experience of trying to make large ripples in a small puddle taught me something. If you tried to approach difficult and controversial issues by working with other people (in this case, both students and faculty) and by putting together the best damn intellectual arguments for your position that you were capable of, you could make real progress toward your goals, even if you weren't around to witness the eventual result of your efforts.

My current job on the staff of the National Research Council involves "stirring the pot," to a degree. The Research Council is a network of committees, composed of distinguished scientists and engineers, that provide scientific advice to the U.S. Government. In the course of performing this function, committees and their staffs often discover underlying problems in the way that the Government manages and supports research or in the way that it approaches a particular technical issue. We propose ways to make the Government's support of research more effective, or to make its technical decisions more soundly based, but we are not always immediately successful in having our suggestions implemented. In fact, sometimes the responsiveness of the U.S. Government makes the old Ursinus look pretty good.

The experience of trying to make large ripples in a small puddle taught me something. If you tried to approach difficult and controversial issues by working with other people . . . and putting together the best arguments you were capable of, you could make real progress.

My experiences at Ursinus—experiences that were only possible because of the close, intimate atmosphere of the College—clearly helped to develop my interest in the ways that institutions manage and respond to change, and ultimately led me to a career in science policy.

Let me conclude by saying that I agree with the comments made by the previous speakers on the program concerning the important connection between science and the liberal arts. Our society desperately needs citizens who are trained to think critically; in government the need is especially acute. The environment of the small liberal arts college, where a cadre of professsors are in close contact with students, can best promote the art of thinking critically. Unfortunately there is no textbook for critical thinking, nor is there a course that can teach it. It is rather something that, like the ability to write clearly, must be part of the fabric of every course in the College. This is the priceless contribution that the liberal arts college can make to a scientific education.

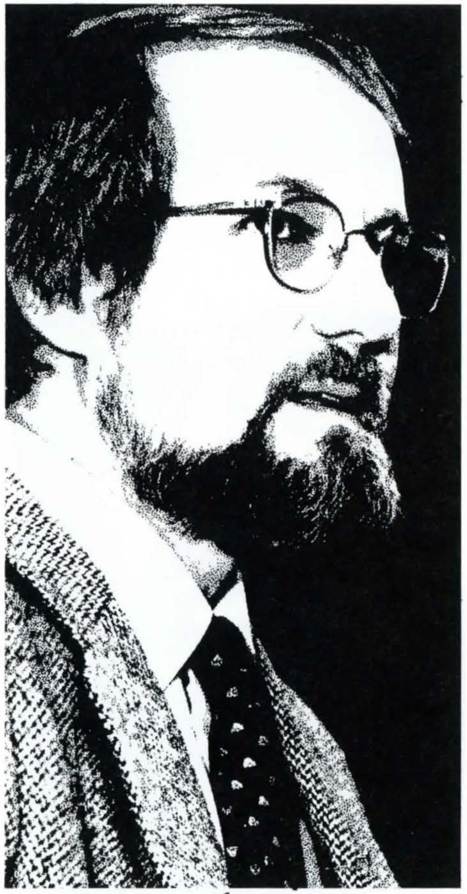
Sometimes the responsiveness of the U.S. Government makes old Ursinus look pretty good.

Robert Simon is a study director at the National Academy of Sciences in Washington, D.C., and is currently editing a book for Science *magazine on frontier chemical research.*

Rick Miller

Ursinus Helps Non-Standard Student Bloom

By Dr. James Stellar, '72



I support the comments of the previous speakers that it is fundamentally important for a college of this size to have a strong science program, and more important, to have active scholars; scholars who are working in the field, not just teaching in the field.

I thought I might illustrate this by taking a somewhat personal tack and showing you how Ursinus has affected me, and essentially permitted me to be in the position of being able to come back to you today.

I am a neurobiologist as well as a psychologist, and I will draw a little bit from that in making some of my points, as well as from my experiences of being a professor at a large university.

What I want to talk to you about today is something I think that Ursinus does especially well. That is to guide what I will label the "non-standard student." Standard students are the admissions officer's dream. They have a 4.0 average and 800 board scores, or close to it. They get lucrative offers from university graduate programs, or they go off to medical schools.

What's often missed is the non-standard student, the student who does not have those credentials. I think that I was probably one of those. If this were my high school, I think most people who taught me would wonder if there had been a mistake that I had been invited back, and especially this thing in the program about my being at Harvard University. I think they thought I would go to college, and that would be the end of it. I would be curious to know if my professors at Ursinus thought the same thing. In graduate school, I did a little better. And my secret may be that I never stopped growing. Maybe you can turn that around and say I never grew up.

In this developmental scheme that I have described, there is a word that comes to mind from a fairly controversial book by Desmond Morris, *The Naked Ape*. He popularized the term, "neoteny," which essentially is the thesis that our evolution is one in which a previous species gave birth to us by having us not develop fully; by having us remain as is with some characteristics of infancy continued into adult life—particularly the ability to learn and to be non-rigid in our behavior.

I am a parent of a 19-month-old child, so I am watching learning take place in detail for the first time, and while I can say that my daughter is not the most flexible person in the world, particularly when it comes time to go to bed, she certainly is extremely flexible and subtle and supple in the way she approaches the world.

One of the crowning achievements of human evolution has been the development of the frontal lobes of our brains. In many ways, we are rats that have gotten large. But in our frontal lobes, we are more than scaled up rats.

As a neurobiologist, I have further examples of this. One of the crowning achievements of human evolution has been the development of the frontal lobes of our brains. In many ways, we are rats that have gotten large: large in body and large in brain. But in our frontal lobes, we are more than scaled-up rats. Our frontal lobes are more than three times the size that they ought to be.

When the frontal lobes are damaged in human patients, the effects on behavior are not striking, at least not at first blush. In the Wilcox card sorting task, a task employed by psychologists and neuropsychologists studying these patients, subjects are told to sort piles of cards containing various shaped objects without any specific instructions. The only instructions that are given are in the examiner's feedback. By the process of feedback, in a relatively short time, both normal and frontal-lobe-damaged patients discover the strategy (for instance, you want me to collect all cards with triangles into one pile.) Now the real test comes when the examiner, without telling the patient, switches the category and decides he or she wants every card with two objects on it, regardless of shape, sorted into a single pile. The frontal lobe patients make a remarkable error here. They almost never learn to change from the original strategy. They are intellectually competent enough to learn what seems a rather subtle task of how to sort the cards, given only the feedback of the examiner, but they cannot change. They are inflexible. They are rigid. By contrast, the normal person, after a few mistakes, changes his or her criteria and begins to sort correctly again.

I think the patient is a model for how intellectuals develop, particularly those who go into fields where creativity is essential.

You can get much the same deficit by subtracting dopamine, a brain chemical which I spend a lot of my time researching, from the frontal lobes. What I find particularly interesting is that this chemical is also extremely important in allowing you to move. That is, if you do not have it, you are rigid; trapped within your own body. Dopamine is also the brain chemical that is activated by cocaine and amphetamines. I do not mean that you should take these substances, only to illustrate that this chemical has to do with motivation and emotions.

This tells us not only that flexibility is important, but where it comes from: flexibility, I think, comes from confidence. It comes from motivation. It comes from the ability to see yourself in a role, to act on that role. And where does the confidence come from? I think standard students probably have that confidence.

I do not think I had confidence when I first came to Ursinus. But I got it here somehow. And I think I probably would not have gotten it if I had been down at the University of Pennsylvania for my undergraduate, as opposed to my graduate training.

Flexibility, I think, comes from confidence, from motivation. It comes from the ability to see yourself in a role, to act on that role.

Something happened up here in the quiet, cloistered environment, where you are not a number, not a lost face, where people at least know who you are, even if they do not know what you are doing and what your name is. Something happened in my ability to feel that I could talk to my teachers in college. That they could talk back to me. And I changed. I do not think I fully realized it until I became a professor at Harvard and had been there a few years. And I have brought a bit of Ursinus with me to Harvard. I create a small teaching laboratory in addition to my courses, where I have a kind of interaction with my students. I use them as babysitters. We go out and have a beer now and then. We talk to each other. I find out what is going on in their lives, and they find out what is going on in my life, and they get to imagine themselves as professors.

Something happened up here in the quiet, cloistered environment, where you are not a number, not a lost face, where people at least know who you are . . . And I changed. And I have brought a bit of Ursinus with me to Harvard.

And I think, that while I felt there was a deficiency at Ursinus in the quality of scholarship on the part of the faculty (compared to a major university where constant pressure is applied to publish—believe me, constant pressure is applied to publish and keep current) there is a resource that comes out of that absence of pressure which allows contact with students. And I think that Ursinus can rescue students like the one I once was from oblivion.

I also think Ursinus can have it both ways. With a sophisticated administration, which I believe you have currently, you can bring up the teaching level so that you need not really sacrifice the academic quality of the faculty by forcing them to teach so much. Yet you can still retain that very precious interaction between teacher and student.

Let me summarize briefly. It is important not to grow up too fast. I see too many students at Harvard who already know not only what they want to take, but what they want to be, where they want to do their medical residencies and so on. And some of them are fine, but a lot of them have problems.

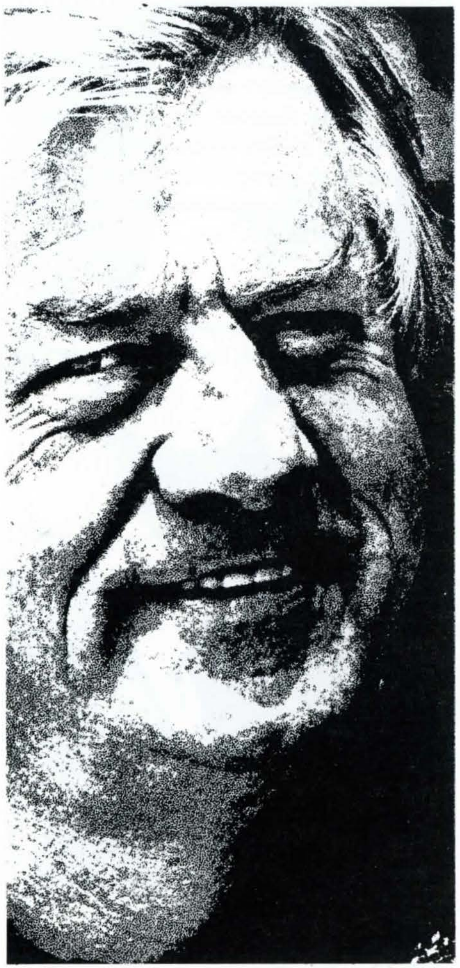
It is important not to grow up too fast, and this college has a way of allowing you to grow up at your own pace that I think is marvelous. It affected me in a very powerful way. It produced an ability to be flexible, and derive from that a basic ability to be confident and creative that comes from believing in yourself, which can only occur if you first know who you are.

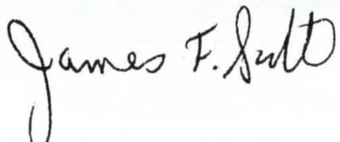

Rick Miller

James R. Stellar is associate professor of psychology and social relations at Harvard University. In 1985 he received Harvard's Phi Beta Kappa Outstanding Teacher Award.

Ursinus Let Him Explore Inner Space

By James F. Scott, '53





Should colleges concern themselves with helping along students who are not working to potential? Is it a special function of the small liberal arts college to bring out the best in such students? In my view the answer to both questions is yes. Let me tell you a personal story.

Not many people can say a next-door neighbor has had a profound effect on their lives. I think maybe I am one of the few who can.

Actually, my neighbor, Mr. Anderson, never played a direct role in altering my life so much as he acted as its catalyst, steering me in a new direction which led me to recognize the value of curiosity and the process of discovery.

Perhaps I'd better explain. You see, it was when I was just finishing high school that my neighbor, George Anderson, first approached me about college. It was a subject I had only tentatively begun to explore my senior year. After all, I had had very little exposure to the idea; no one in my immediate family had gone to college. So to me, this college notion was something uncertain and mysterious. But Mr. Anderson was able to change that for me. He was an Ursinus graduate and obviously thought very highly of attending college in general, and Ursinus in particular. (Ursinus needs more George Andersons!)

Soon I was applying to Ursinus and going to Collegeville for an interview. But the odds in favor of receiving an acceptance were slim. I suppose I knew in the back of my mind that since my high school grades hadn't been all that good, my chances of getting into Ursinus were minimal.

But Ursinus accepted me, taking a chance that I'd respond well to the new environment at Collegeville. I made the obligatory trip next door, of course, to show Mr. Anderson my letter of acceptance. He reacted, I remember, in a sort of welcome-to-the-club way. He smilingly congratulated me and presented me with a plaster of Paris replica of the Ursinus College seal. I hadn't expected that at all, but I was proud to take it. It is a memento I still possess and cherish today.

After only a short time on campus, however, I began to feel that Mr. Anderson's confidence in me had been misplaced. I very nearly flunked out my freshman year. But as time went on, I began to sense something changing within me, although I couldn't put a finger on it. I decided I had to stick it out at college.

As time went on, I began to sense something changing within me, although I couldn't put a finger on it. I decided I had to stick it out at college.

Gradually I met people and they became friends. Before I graduated, I knew most everybody by name. I became active in the Curtain Club on campus. I took my decision to participate for granted, although now I understand that at some larger universities, the opportunity to get directly involved in stage production is restricted to drama majors or considered off-limits to all but a small clique of students.

I also participated in the annual performance of Handel's *Messiah*. *The Messiah* was an incredible experience for me—rehearsing as a group, trying to master a new skill, and finally getting to perform on stage with the various singers imported to perform the featured solo sections. It required a tremendous amount of practice and diligence to learn the music under Dr. Philip, but the thrill of the performance, of hearing everyone boom out the chorus, of being surrounded by the basses, baritones, tenors, altos, and sopranos who were my classmates, has given me a memory I actually feel physically each time I hear that selection of music.

Beyond the social life at Ursinus, I also began to take an interest in what was being taught in my classes. I started paying more attention to the lessons, and what I learned was fascinating. At some point, college had become interesting.

I think it helped that my classes were so small, usually only a dozen students or so. It certainly allowed for more interplay between the students and the instructor. The professor seemed more like an older friend to me and less like an authoritarian figure. I began to ask more questions, and I found out the more I discovered, the more curious I became.

I remember in particular a philosophy class I had in old Bomberger Hall. The professor, Charles Mattern, had a deep, resonant voice and he reveled in teaching classical Greek philosophy in the Socratic Method, answering a question with one of his own.

Many times I can recall Professor Mattern starting class by closing the big wooden shutters inside the classroom so that we were completely sequestered from the outside world, just a handful of students sitting in the darkened room listening to a disembodied baritone voice contemplating the ancient philosophical arguments about life and the human mind, reason, and perception.

He made life a little difficult for the student, because as he held the class suspended in thought, he would force students to respond to his questions on the spot. He wouldn't take a half-baked answer. I might think I had made an astute observation and by his reaction I could see how my choice of words had changed the meaning of what I had meant to say. This would frustrate me at times, but by requiring me to respond, he made me think about the use of language. And I see now that by being forced to defend myself, I learned.

We were completely sequestered from the outside world, just a handful of students sitting in the darkened room listening to a disembodied baritone voice contemplating the ancient philosophical arguments about life and the human mind, reason and perception.

Another professor, my math instructor Foster Dennis, was not quite as much of a salesman as Mattern. Dennis was pretty forgiving with his students and didn't demand strict discipline. But his teaching manner made it possible for me to ask questions I might not otherwise have asked.

Sometimes in mathematics, a minute detail can make you stumble. Understanding a complex theory may hinge on comprehending its smallest part. Soon, I felt as though our small class was being opened up to a whole new world. Our discussions were voyages of discovery.

For one thing, I discovered mathematics was never like arithmetic. It became apparent to me that mathematics was structured much as a picture was; it contained shades and shapes and even dimensions.

By my senior year, I had acquired a good deal of confidence because of the consideration given to me by the Ursinus faculty and staff and the feeling of belonging I ascribe to the benefits of a small campus. I had also adopted a curiosity about the world which had been fostered by my experiences in Collegeville. These things allowed me to graduate from Ursinus in 1953—the year I got straight A's.

I went on to the University of Delaware, receiving a Master's Degree in mathematics there in 1955. After two years at General Electric, I started working for Caltech's Jet Propulsion Laboratory in 1957, only months before the first Russian Sputnik.

In the almost 30 years I have worked at JPL, I have witnessed the whole unmanned exploration of our solar system, starting with the moon, then the inner planets—Mercury, Venus, and Mars, and finally the outer planets—Saturn, Jupiter, and Uranus. My part in this has been challenging, interesting, and exciting—supervising the development of JPL's first trajectory and orbit determination programs, leading the development of the control center software for some projects, and now performing mission operations system engineering for the forthcoming Magellan mission (a radar mapping mission to Venus scheduled for launch in 1988).

To my mind, my rewarding career at JPL would not have been possible if Ursinus had not bent its entrance criteria to allow my journey of discovery to begin, and had it not had the environment to allow it to continue. It was George Anderson who directed me toward Ursinus, but it was Ursinus which changed my life! I am sure many an Ursinus graduate can tell a similar story.

I feel, therefore, that not only do small liberal arts colleges have the responsibility to help students work to their potential, but I believe they have a responsibility to make value judgments above and beyond SAT scores.

I discovered mathematics was never like arithmetic. It became apparent to me that mathematics was structured much as a picture was; it contained shades and shapes, and even dimensions.

I work with many recent college graduates. Almost to a person, those from small liberal arts colleges have the ability to communicate and get along with fellow workers well. Those from large universities with comparably good grades may be better trained technically, but are generally lacking in interpersonal relations skills.

The advanced technological projects today require more and more teams with inter-disciplinary participants who can interact and work well together. The separate researcher alone in his laboratory is a vanishing breed. Ursinus and other liberal arts colleges must produce the best-educated, most well-adjusted, most knowledge-hungry graduates this nation has ever seen, if we are to remain a technological leader of the free world.

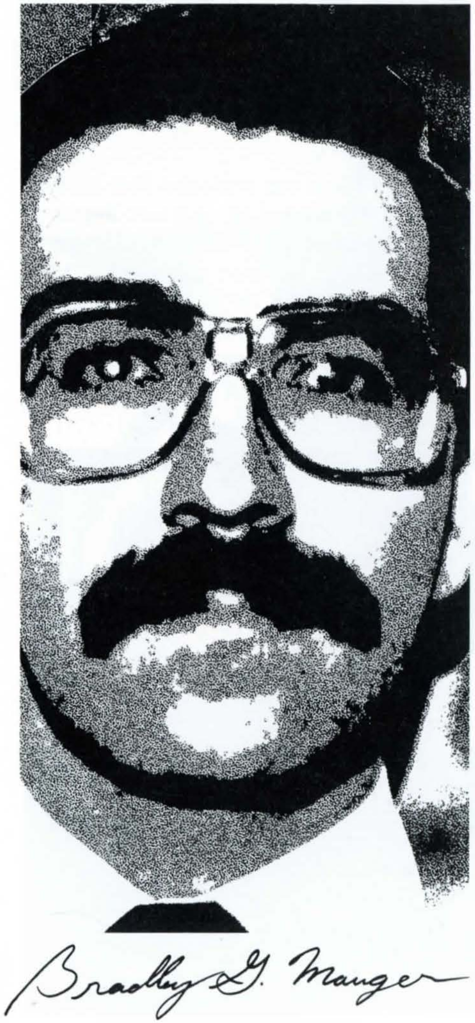
But a good, a fulfilled life is more than one's career, more than the money game. It is a life of increased perceptions, involvement, and enjoyment in all its aspects. Perhaps the most important part of a liberal arts education is the increased chance of a happier, more rewarding life.

James F. Scott was graduated from Ursinus in 1953. He earned his master's degree in mathematics from the University of Delaware in 1955, and after two years with General Electric, went to work for the Jet Propulsion Laboratory of the California Institute of Technology. Today he is mission operations system engineer for the Magellan probe of Venus, scheduled to be launched in 1988.

Rick Miller

Finding Problem Is Scientist's Hardest Task

By Dr. Bradley G. Mauger, '76



One of the biggest challenges often facing scientists is not finding the solution to a particular problem, but rather, determining precisely what the problem is in the first place.

Scientists must have the ability to frame problems properly after sifting through ponderous amounts of raw data.

No one avoids this situation entirely. Everyone encounters it in Algebra I, if not sooner. After weeks of learning to solve equations and factor out polynomials, the student sits down to a big test. The first part of the test seems straightforward, almost easy. But then on the second page, there it is: the bane of every junior high student, the dreaded "reading problem." The algebraic equation is stated in words, and first has to be derived from them before it can be solved. Sometimes this is complicated by the inclusion of extraneous information which is not needed to solve the problem.

Scientists (as well as engineers, economists and others) have always had to state problems properly first before they could solve them. Contemporary scientists have a harder task than their predecessors, *because* of the excellent tools available for modern research.

The universe is, and always has been, a very complicated place. The scientist of a few decades ago had only crude tools with which to observe it. Simple theories could be used to model the bulk motions of the planets, the basic laws of supply and demand, or the causes and effects of operant conditioning. Today's scientists are forced to examine the universe with an almost frightening clarity.

Until a few years ago, for instance, the rings around the planet Saturn were "well understood." With the fuzzy pictures available through telescopes, scientists explained the rings as simply particles in orbit, and dominated by gravitational forces. This was fine until the Voyager Program brought back more detailed information. It turned out that model-predicted gaps in the rings had been in the wrong places. Strong electrical and magnetic fields, previously unknown, were discovered. Some rings appeared to be twisted or braided. So complicated was the structure of the rings, that it was now doubtful that any one model would be able to explain them. NASA's Tracking Data and Relay Satellite System (TDRSS) can relay data from satellites at a speed equivalent to 37 million printed characters (bytes) per second. One sees that modern tools can collect information faster than scientists can absorb or explain it.

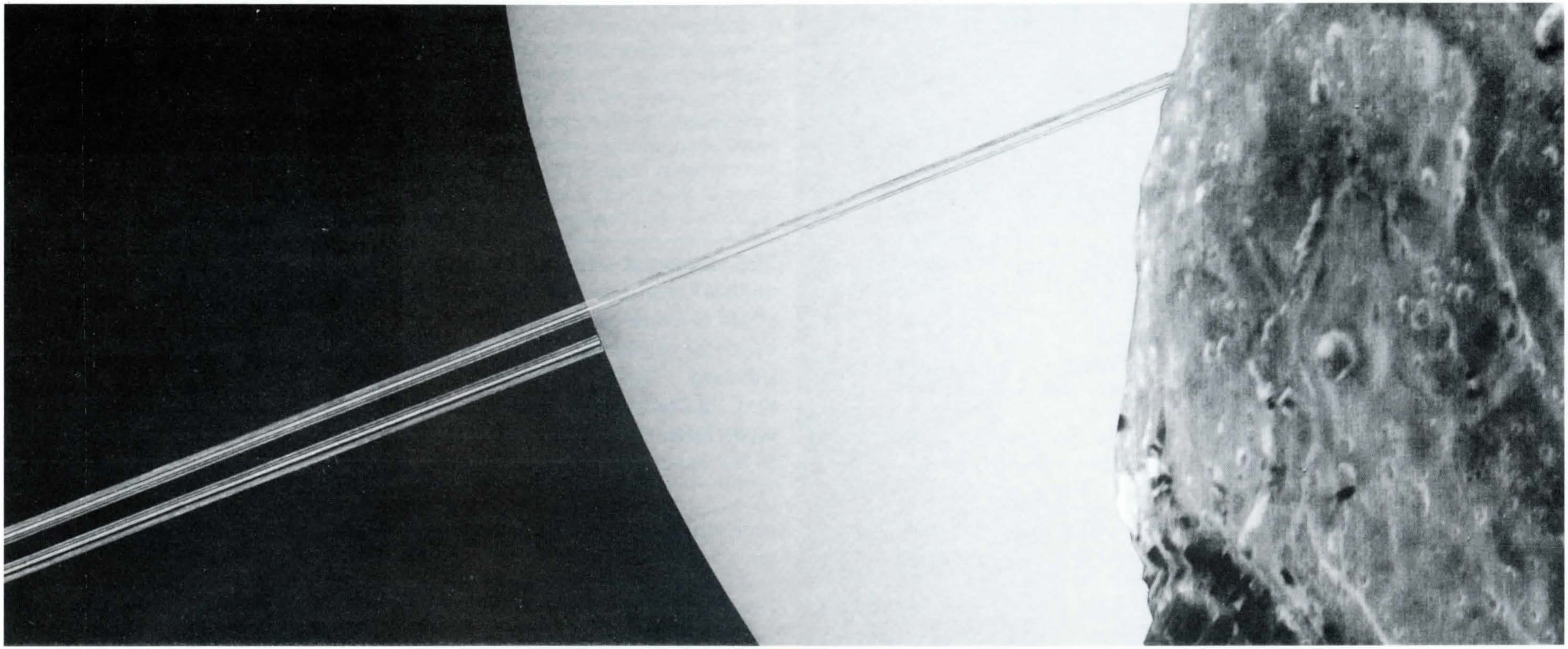
Algebra reading problems and Saturn's rings have something in common: Both contain raw information which must be organized before it can be analyzed. Some of the information is important; some is not. The algebra teacher uses reading problems to determine whether students can apply the mathematical tool they were just taught. The scientist, who is that former algebra student turned adult, must go beyond rote repetition of tools learned in school, look at the information, and determine how it "should" go together. His or her focus must be on those things which do not "behave" the way they "should," the pieces of the puzzle that will not fit, the exceptions to the rules.

How can a school prepare future scientists to frame and solve problems properly? It is doubtful there is any school that offers a class called "Clever 201," or a degree in "Smart." No, the way to learn how to find something new in a field is first to learn the basics very well. Learning the "state-of-the-art," without first learning the basics, is a poor investment of time and energy. Next week, the state of the art will move on. Without a good basis on which to build, it is not possible for the scientist to keep up with progress. It is a deep knowledge of how things work that allows a mechanic to fix a new kind of car, or lets a machinist make a part for a machine he has never seen before. A comprehension of the basics, coupled with experience, creates a level of understanding that approaches second nature.

Today's scientists are forced to examine the universe with an almost frightening clarity.

A college should not attempt to teach the state of the art in all subjects. To do so would be a disservice to its students, if the basics were to be shortchanged in the process. Colleges are, however, actually businesses, and subject to market pressures. Sometimes a college, in an attempt to increase enrollment, will short-circuit the liberal arts to teach a more specialized curriculum. Such courses are often touted as being more "relevant." And generally, graduates of such schools do very well after commencement. Many employers prefer hiring graduates who need little additional training. The negative effects of a narrower specialized education may manifest themselves only later in such scientists' career development.

Vocational advancement often requires job changes. A scientist may find out several years after graduation that engineering jobs provide more oppor-



Jet Propulsion Laboratory Photo

tunity. An engineer may find he wants to move into program management, or start his own company. The problems that a scientist must solve are very different from those faced by a businessman. A broad-based liberal arts education can provide the background to allow such growth.

Modern tools collect information faster than scientists can absorb or explain it.

Since graduating from Ursinus, I have had the opportunity to meet and work with graduates of many other colleges and universities. At first I envied some of their prestigious schools and exotic course options. Only later, did I realize that these graduates had not had upper level courses with five to 10 students, as we had at Ursinus, but with 50 students. Most of them had had contact with their professors only a few times a semester, compared to the daily contact we had with ours at Ursinus.

The closeness of the faculty and students assured that we received the individual attention missing at so many other schools. When I made a mistake on a physics test, it was Dr. [Martha] Takats or Dr. [Evan] Snyder who applied the red ink. When I tried to bluff my way through a calculus problem Ms. [Blanche] Schultz or Mr. [Richard] Bremiller were quick to point out the error of my ways. This is the kind of personal contact which gives students an added incentive to learn.

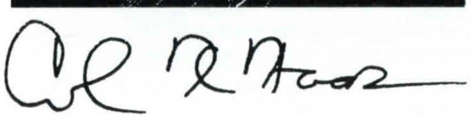
Learning the "state-of-the-art," without first learning the basics, is a poor investment of time and energy. Next week, the state of the art will move on.

In science or in any field, one must know the basics before moving on. Ursinus has a history of teaching these basics and teaching them well. No matter how complicated the future might become, a student will always need to start at the beginning. As long as Ursinus continues to stress the basics, there will be a place for the College in this future.

Dr. Mauger was graduated from Ursinus in 1976 with a B.S. in physics. He later received his Master's and Ph.D. from New Mexico State University. He is a senior systems engineer for Space Communications Company, working at the Air Force's Consolidated Space Operations Center in Colorado Springs, Colo. Previously, he studied cosmic radiation under a National Academy of Sciences grant, and worked as a system engineer on NASA's Tracking Data Relay Satellite System. His work forces him to move often; he describes himself as "a high-tech gypsy."

Most Wanted: Insatiable Curiosity

By Dr. Carol K. Haas, '70



Streaks in carpet samples, finish roll deposits, high temperature fluorination catalysts, sulfur compounds in coal, multi-metal clusters and strained ring organosilanes—none of these topics ever found its way into my organic or physical chemistry classes while I was at Ursinus. Neither did resource allocation plans, performance reviews, career development discussions, staff reviews, or capital expenditure budgets. Yet each in its own time, (and often many at the same time) has been the focus of my attention during the 16 years since I left Ursinus.

I spent four years of graduate school focusing exclusively on learning and "doing" science at the frontiers of organometalic chemistry. At Du Pont, I have spent several years in widely divergent research areas as a research scientist, followed by 12 years with even more widely diverse research interests. Increasingly, my emphasis as a technical supervisor has had to be on the supervision and development of people.

It is the reality of the work world that assignments change and employees are asked to perform tasks for which they were not formally prepared. So how should an undergraduate institution prepare its graduates for such a wide range of work assignments?

The successful scientist in the industrial world is one who is unafraid to tackle problems in fields in which he or she has had no formal training. Many, perhaps even most, of the key industrial research areas have no formal counterparts in the typical science curriculum. Textile sciences, high temperature/pressure chemistry, heterogeneous catalysis, fluorine and silicone chemistries are all fields which provide jobs for thousands of chemists. Yet rarely do these topics appear in a college curriculum.

Does that mean we are failures in the way we approach science education? Not necessarily. In fact, if we try to educate student scientists only in those areas of knowledge which employ scientists, we will surely fail. In the 40-year career of the typical scientist, the prime research areas change several times.

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For example, 40 years ago, the synthetic fibers industry was in its infancy, with the world's first nylon plant not yet 10 years old, and high-performance materials like Teflon® fluoropolymers were not yet discovered. The computer tools I use at my desk daily were not yet on the drawing board during my time at Ursinus. So trying to anticipate the fields that will employ scientists is a hopeless task, and not a rational approach to education. Instead, we need to teach those areas that help a person learn how to be a scientist, and depend on the individual's own initiative to help him or her tackle specific fields of research in the future.

What sorts of information and skills help students learn to be scientists?

Students first need to learn the basic vocabulary of their chosen fields. As painful as the process can be, a chemist simply cannot function without a working knowledge of organic nomenclature, the periodic table, trends in physical properties with changes in structure, and the basics of thermodynamics. Beyond that, one of the most valuable experiences any scientist-to-be can have is practice in defining, analyzing and solving problems in science.

It is awe-inspiring to watch the way an experienced industrial scientist tackles a new assignment. Typical problems are presented to such a researcher in everyday, not-very-scientific terms. Such requests as "we want fewer deposits on a reactor's wall," or "we want a fabric that feels softer," must be analyzed and translated by the scientist into lists of physical properties to be studied and evaluated. He or she must learn what is critical to the desired outcome, quickly consume and understand background literature, formulate a test program and timetable which will answer the key technical questions and allow an optimum approach to be defined within the constraints of time and money that exist. If a solution cannot be found meeting those constraints, he or she can tell us why, and what it would take to overcome the obstacles.

Such a scientist possesses a sense of timeliness: he or she can tell us whether this problem is worth spending three years or two weeks to solve. Knowing when to stop working on a problem is often harder than deciding which problems to work on.

A scientist has not solved a problem if he does not communicate its solution effectively. It is not sufficient to come up with a good solution if you cannot convince the rest of the organization to adopt that solution. We in management spend much more of our time communicating, than we do in defining and solving problems. Persons in direct research write reports and proposals or make oral reports almost every day.

Do we teach these attributes well? Most scientists are well-grounded in using the literature, in defining and testing hypotheses, and in carefully recording and analyzing data. What we

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haven't learned to teach well is the ability to relate practical problems to fundamental physical properties which can be measured and used to design optimum solutions. In the area of communications, liberal arts graduates generally have an advantage over their peers from other types of schools. (Oral and written communications skills are the ones most frequently cited as needing improvement in our performance evaluations and individual development plans at Du Pont.)

Writing and speaking skills may be the most critical ones brought to a career in science from a liberal arts education, but they are not the only useful ones. A working knowledge of economics, political science, business, psychology, ethics, foreign languages and cultures, environmental issues and labor law can come in handy during a typical work day. Again, if I examine my recommendations for formal continuing education and professional development to those I evaluate, at least two-thirds concern the liberal arts. Those we hire tend to arrive with finely-honed scientific skills needed to do the job; but the key to their future success is the development of a broader perspective of what we are trying to accomplish beyond the laboratory.

So what does a successful industrial scientist need from an undergraduate education? In summary, I suggest the following are essential:

—A solid grounding in the basics of the chosen scientific field, hopefully closely related to the first job assignment;

—A well-developed laboratory technique in a chosen field, and familiarity with instrumentation in that field;

—Problem solving skills;

—Data analysis skills, including a passion for accuracy and honesty in reporting data;

—A friendly working "relationship" with computers;

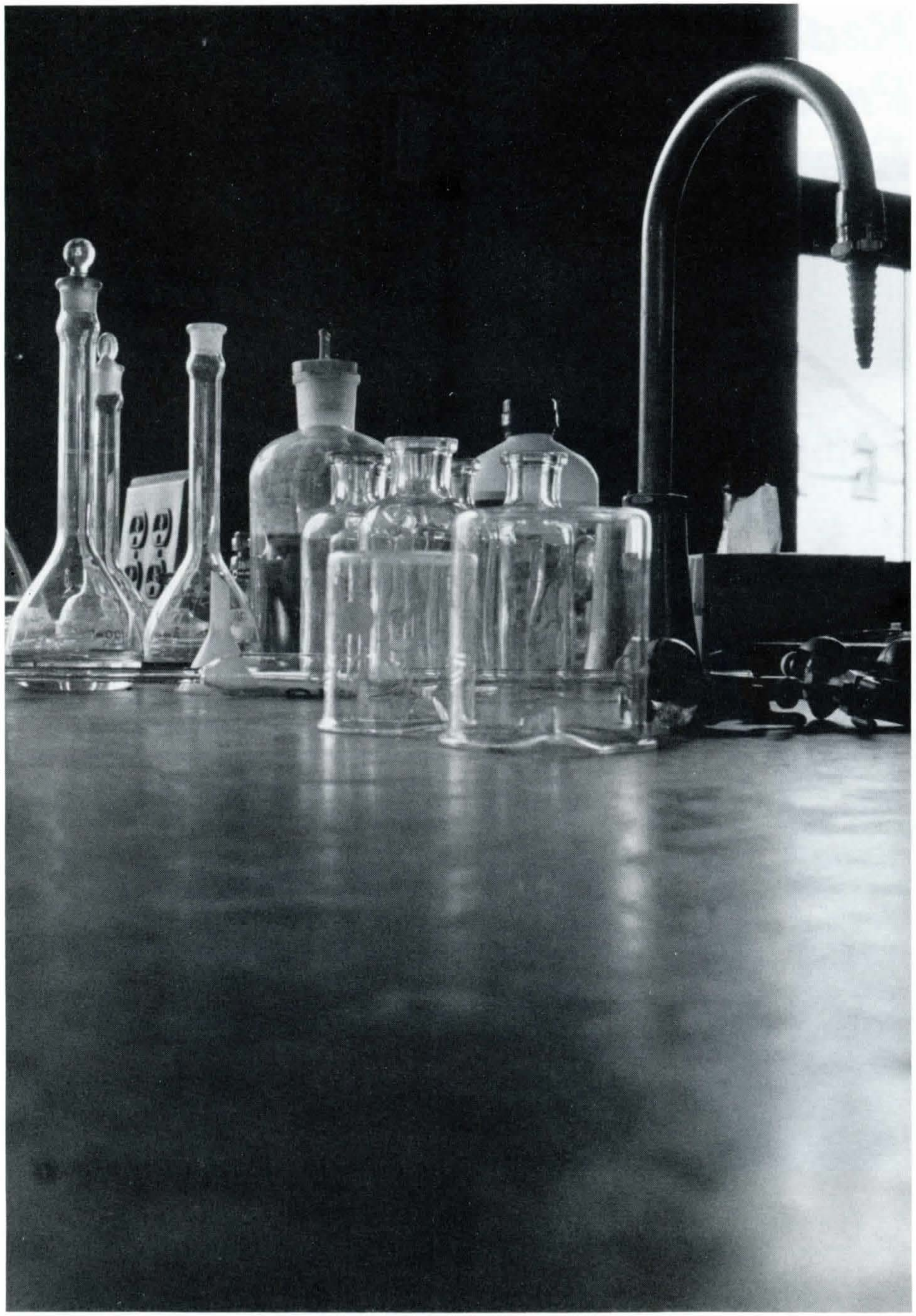
—Communications skills and no fear of public speaking;

—Broad exposure and working knowledge in a variety of classical liberal arts areas,

A successful scientist needs, above all else, an insatiable curiosity to learn new things, both in scientific and in other fields.

But above all else, the successful scientist needs an insatiable curiosity to learn new things, both in scientific and in other fields.

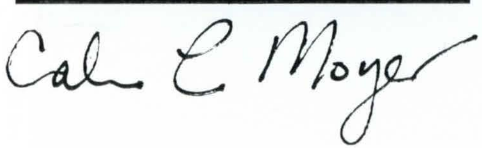
Dr. Haas is supervisor of research and development in the textile fibers department of Du Pont's Carpet Fibers and Fiberfill Division, Seaford, Del. She holds a Ph.D. from M.I.T., and is president of the Ursinus College Alumni Association.



Rick Miller

Real Research: Practical Or Esoteric?

By Dr. Calvin Moyer, '63



A little over 25 years ago, I enrolled in the Ursinus physics program, because I intended to become a scientist. It is a testament to the clarity of my vision that on the first day of classes, I changed my major to chemistry out of respect for my high school chemistry teacher, to whom I had a deep emotional tie. Nine years later, I finished my graduate studies, and started work as a Ph.D. organic chemist.

To this day, I have not done any "real" chemistry at Du Pont, where I have been employed since graduation. After two years each of engineering work in research, customer support work in the plant technical services area, and customer development in end-use-research, I took a 10-month recruiting assignment with the corporate employee relations department. That appointment has continued over the last 12 years to the present with a string of assignments in the personnel field. It is from this perspective that I look at the "growing" of scientists.

What should be the vision of excellence in a scientist? The exoteric path which leads to new products; or the esoteric path which leads to the pinnacle of discovery? True success requires both. Without this blend there is a lack of true depth in what a scientist becomes.

So-called "scientists" today are fundamentally of two types. There are the "technicians," who have honed their ability through training to become creators of state-of-the-art products. They are as up-to-the-minute as the things they produce, both in data definition and problem solving. In contrast there are the "true scientists," the pure researchers, who have developed the capability to transform given data in front of them into that which serves the larger community. Both types of scientists are real. Both are needed. But they march to different tunes. The first is a pursuer of new states, someone who can surmount all obstacles to create the desired results. The second is a commander of processes which change both individuals and the world around them.

What then should be the vision of success, the vision of excellence in a scientist? The exoteric path of substance, media, energy and conditions which leads to new products; or the alchemist's esoteric path of earth, air, fire and water, which leads to the pinnacle of discovery and knowledge? True success requires both. It comes from a blend of intellectual capacity in science and philosophy, and emotional capacity in art and religion. Without this blend there is a lack of true depth in what a scientist becomes.

How then do we "grow" such scientists? The view of the teacher should be no different from that of the student. It is a matter of maximizing potential, not just in acquiring knowledge, but in developing the means to understanding. The uniqueness of the scientist grows as he or she grows in the ability to overcome limits and boundaries, in competence, in mastery of the surrounding world, and in service to purposes beyond self.

Ursinus has had for some time all of the necessary conditions for the nurture of outstanding scientists. The success of the process has been more evident than the process itself. Each of us has carried away a piece of that process. The extent to which each of us, or Ursinus, is successful, is dependent on our awareness of and continuation in, that growth process.

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Dr. Calvin Moyer has worked for Du Pont for the last 18 years, and is currently an administrative and planning assistant in that firm's polymer products department. For the last 12 years, his work has consisted of personnel assignments. He holds an M.A. and a Ph.D. from Harvard University in organic chemistry. He and Urve Viitel Moyer, '62, were married in 1963.

Flexibility Is A Matter Of Degree

By Urve Moyer, '62

Looking back on a career spent in both business and traditional settings, I'd like to share my thoughts on the preparation Ursinus furnished me to deal with these roles.

I have certainly found the skills I acquired in college to be in fair demand, and those skills have enabled me to find work that has been both challenging and enjoyable. Because of my educational background, I was able to work when I wanted to and stay home with my family when my children were young. I have to attribute that flexibility to a solid background in a discipline that couples a knowledge of basic facts with a regimen of problem solving.

The positions I have held have drawn more on my ability to learn and process new information than on the utilization of what I already knew. Sometimes I

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have even felt that a scientific education is just an exercise designed to demonstrate that students can absorb what the business world might throw their way. I think Ursinus prepared us well by teaching us to think and analyze, and by not turning us into technicians—a breed guaranteed to find today's fast-moving technological advances frustrating.

But I do feel that I missed something at Ursinus as a science major who deliberately chose a liberal arts college: the arts and humanities. These were said to be available to us, but most of the advanced courses in them were scheduled in the afternoon when science majors had labs. We were lucky to be able to attend some of the survey courses in the arts. And I remember auditing even those because of scheduling problems.

I really miss having had a better arts education . . . I hope the new generations take the opportunity to strive for excellence outside their formal disciplines—not for any materialistic gain, but for the sheer joy of it.

What we lacked was a system which encouraged cross-matriculation. (The same thing probably happened to arts majors who had an interest in science.) We didn't (or couldn't) take advantage of all the people and knowledge so readily available to us at that one time in our lives. Instead, we comfortably fell into separate arts and sciences academic mini-communities.

I really miss having had a better arts education, since in leisure time, such interests continue to be a major endeavor for me. I wish I did not have to go to the books so often, and that more facts just fell into place. I wish I had spent more time talking with people who had spent a large portion of their time pursuing the arts.

I hope the new generations coming through Ursinus take the opportunity to strive for excellence outside their formal disciplines—not for any materialistic gain, but for the sheer joy of it.

Mrs. Moyer earned her B.S. in chemistry from Ursinus 1962, spent a year working for Rohm and Haas, and two, for Arthur D. Little before earning an M.S. in organic chemistry from the University of Florida. She then spent 13 years at home rearing two children into semi-adulthood. For the last five years she has been with Du Pont, first in applied research in the manufacture of Mylar, a polyester film, and currently as quality coordinator at the Viton and Hytrel plant site.

Liberal Arts Education Prepares Minds

By Willis G. Frick, '69

When I left Ursinus to attend graduate school, I had every intention of pursuing a career in chemistry, my major. However, after only one year at Princeton, the Vietnam War caused a major change in my career plans. First in the Navy and for the last 11 years for the Southern California Edison Company, I have worked as a nuclear engineer, not a chemist. Consequently, I have not used most of what I learned about chemistry at Ursinus.

Do I think that my time at Ursinus was wasted? In hindsight should I have attended a different college and majored in nuclear engineering? No! Ursinus taught me how to learn; how to think logically; how to approach and solve complicated technical problems; and how to apply the scientific method to the problems I face. My liberal education at Ursinus taught me how to make ethical decisions and to understand the consequences of my actions.

Ursinus taught me how to learn; how to think logically . . . how to apply the scientific method to the problems I face.

In my 15 years as a nuclear engineer there have only been a handful of times when I could not complete an assignment because I did not have the necessary specific technical background. The learning and thinking skills I acquired at Ursinus, and the intensive self-study have provided me with the required knowledge of my technical specialty. Further, few problems are solved by technical considerations alone. Many of my assignments involve understanding complex interactions between several technical areas. Finding and stating the problem is often as difficult as the solution. Time is always a constraint, as each hour of delay in returning a nuclear generating unit to service costs our customers $50,000 or more. My freshman year in CMP (Chemistry-Math-Physics) forced me to solve complex interrelated technical problems quickly! There was never enough time to study all of the interactions between the chemistry, physics and math, which were the essence of CMP.

I must specifically consider the impact of what I do on the public health and safety. For persons in the nuclear power business, these are not idle or hypothetical questions.

Later I had the chance to apply the logical thought process to problems without textbook solutions, that is, to do research. At graduate school I realized one of the most important things I had learned at Ursinus was how to approach a scientific problem. The logical gathering of pieces of information, their correlation and the development of an experimental plan to extend the available knowledge were among my most important lessons.

In addition to the questions of business ethics found in any organization, I must specifically consider the impact of what I do on the public health and safety. For persons in the nuclear power business these are not idle or hypothetical questions. Specific, judgmental decisions which affect public health and safety must frequently be made. They are not easy or simple decisions. They often include complicated technical arguments. They have significant impact on the operation of the plant and involve substantial monetary impact on my company.

Am I helped by specific courses I took at Ursinus? Did I even take logic and ethics? No. I took neither logic or ethics and I do not remember taking any course whose description or objective included "making ethical decisions." But I did learn how to make these decisions at Ursinus. Ethical decisions require you to understand the implications of your acts on your fellow workers, your company and society as a whole. My liberal education at Ursinus laid the foundation for my understanding of the structure of our society and its history, and it assists me in understanding the implications of my actions. It was much more than the courses I took at Ursinus which provided me with this basis. The example set by the professors, the structure of life at Ursinus and the structure of the institution itself were also important factors.

I took neither logic nor ethics . . . but I did learn how to make these decisions at Ursinus.

I learned to be a scientist at Ursinus.

The education of a scientist is more than rows of courses with columns of facts. The scientist must know how to think and how to learn. He must understand his place in society and life. I learned to be a scientist at Ursinus.

Mr. Frick is supervisor of planning for the Southern California Edison Company's San Onofre Nuclear Generating Station in San Clemente. After graduating from Ursinus in 1969, he did graduate work in chemistry at Princeton University.

The Way To Encourage Young Scientists

By Debra Kamens
Director of Communications

Every year for five days in March, Helfferich Hall is transformed from basketball courts into a melange of scientific apparatus. High school students from all over Montgomery County cart in display boards and brown boxes filled with the evidence of their past months' hard labor.

A din of voices and activity reverberates through the hall as approximately 450 students construct their exhibits for the annual Montgomery County Science Research Competition. The competition, which celebrates its 30th year in 1987, has been held at Ursinus since its inception. It is cosponsored by Montgomery County business and industry, the Montgomery County Science Teachers Association, the county Intermediate Unit, and Ursinus.

"Clearly the College, with its excellent science reputation, has nurtured interest in science for a very long time," says President Richard P. Richter. "To continue to provide leadership in this area that we've come to be known for, we believe it's important to support the competition."

The science competition offers an opportunity for high school students to develop creative scientific projects, to exchange ideas and scientific data, and allows students to view work done by others with similar interests. The projects are the result of much time, effort, substantial research and thought. Students may seek experts in the field to serve as mentors—to get ideas and advice. In developing their projects, Montgomery County students have had the opportunity to work in a number of laboratory settings in the Philadelphia area, among them the Fox Chase Cancer Center, Wistar Institute, Graduate Hospital, the Academy of Natural Science, and Morris Arboretum.

Why is it important for high school students to be involved in scientific research?

Bob Stamper, a biology teacher at Cheltenham High School, has been involved with the competition for about 20 years, serving as director for the last six years. A Pennsylvania NASA Teacher in Space semi-finalist, Mr. Stamper is proud of the students he sends to the competition—many of whom leave with top awards.

"We like students to begin as soon as possible because the opinions and ideas that students gain about science, about technology, about life in general, fairly well develop in middle school years," he says. "If they get a good feeling in middle school years about what the scientific process really is and what it *means*, that will make them better citizens for the future."

Ronald Hess, professor of chemistry at Ursinus, has been associated with the competition for 18 years. He serves as the College's representative to the competition as well as a judge. Among other responsibilities, he recruits approximately 15 students—many who assist on a volunteer basis—from the Ursinus campus, who help set up and direct the high school competitors.

"Clearly an early involvement in science is likely to give the student a good feeling about the subject," says Dr. Hess. "And if the student has a natural fascination for scientific things, clearly he'll start thinking in those terms."

Although a college professor, he is a strong supporter of the high school level event.

"I'm a sports-oriented person and I've always been that way," notes Dr. Hess, who is an active coach of his son's Little League and religiously watches all of his games. "But I do feel there's too much recognition given to the athlete and not enough to the scholar. The science competition is one of those few occasions where scholarship can be rewarded in the public eye."

Dr. Hess volunteers his time to the competition for a number of reasons. "I've always been a strong advocate of this College because I believe in it—education in general—but specifically, Ursinus College. And of course, I would like to think that some of these good students who come to the science competition would be impressed with this institution—by what they see here on campus, by what we talk to them about—so that they might like to apply to the College."

But there is a larger reason for supporting the competition. According to the American Council on Education's recent report entitled *Towards a National Policy for Undergraduate Science Education*, the actual number of college freshmen indicating an interest in science has dropped by 33 percent from 1975 to 1984.

"I agree that there is a national crisis," comments Mr. Stamper. "When you see a situation where Japan produces 1,000 scientists and technologists for each lawyer and we produce 1,000 lawyers for each scientist or technologist, there's no doubt that something is wrong. One of the reasons might be that there's a general perception on the part of kids that science is more difficult than other types of work that can be done.

"And of course the biggest crisis is going to be in science education. In about 5-7 years, the expectation is that at least half of present science and math teachers will retire. And there's

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nobody to replace them."

The solution, although certainly a complex one, might be to begin by making science education more relevant, more interesting, more exciting.

Dr. Hess agrees, "There has to be a proper environment at all levels—middle school, high school and college. I think one of the problems with scientific education is that too many times in the classroom, teachers themselves do not show the enthusiasm or excitement that they should for the work they're in."

Students participating in the Montgomery County Science Competition learn the value of initiative, get a strong sense of independence, and understand the necessity of perseverance, according to Dr. Hess. But they also get a sense of excitement and involvement that they might not otherwise experience.

"I think that talking with the students is more exciting than the exhibits," says Dr. Hess. "I guess one of the greatest satisfactions I get as a teacher is when I have a student come in to see me about a subject he or she doesn't understand and by some example that I can give, or something that I can say, you see the eyes light up—'Ah! I've got it!' And I think that one gets that same kind of satisfaction when you go and talk to the students at the competition. There's a great deal of satisfaction that comes out of seeing a student's eyes light up when he or she is talking about the experiment. That's really the fun—that's the most important part."

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Science and the Liberal Arts
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