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The Role of Liberal Arts in Science Education

An address to the American Society of Military Engineers, November 12, 2003

Steven C. Bahls, President, Augustana College

When I think about the role of great scientists, I often think of the words of British scientist and mathematician, Jacob Bronowski. He wrote, in The Ascent of Man: "That is the essence of science: ask an impertinent question, and you are on the way to the pertinent answer." Great scientists sometimes ask impertinent questions. Because liberal arts colleges encourage their students to ask difficult, and sometimes impertinent, questions, I believe liberal arts colleges are ideal places for educating the next generation of scientists.

Only three percent of America's college graduates have graduated from small liberal arts colleges, yet their achievements in the sciences are disproportionate to their numbers. Graduates of liberal arts colleges are twice as likely to earn a PhD as graduates of the typical college and university. Graduates of liberal arts colleges have an impressive record in the nation's scientific community. Nearly 20 percent of the scientists who were elected to join the National Academy of Sciences were graduates of liberal arts colleges.

Why is it, then, that graduates of liberal arts colleges are disproportionately successful in science? It seems counter-intuitive to some, given that liberal arts colleges admittedly cannot compete with the huge numbers of science courses offered by large, publicly funded universities. Likewise, fewer big-name scientists teach at liberal arts colleges.

I submit that there are three reasons why graduates of liberal arts colleges are so successful in science and engineering careers. First, liberal arts colleges allow students to understand scientific problems and processes within the larger context of the humanities and arts. Second, application of the sciences to real-world problems requires the kind of critical thinking that develops through a liberal arts education. Third, liberal arts colleges are in an ideal position to offer students a more personalized education, often with direct experience in research. As a result, liberal arts college graduates are better prepared for graduate school and government and industry positions

Let's start by considering the opportunity to study science in the context of the humanities and arts. I was reminded of the importance of viewing science in a broader context when I was reading the Science Times section in the November 11, 2003 edition of The New York Times. It was a special edition commemorating the 25th anniversary of the section. The lead article was entitled, "Does Science Matter?" The authors, William Broad and James Glanz, wrote, "The public seems increasingly intolerant of grand, technical fixes, even while it hungers for new gadgets and drugs. It has also come to fear the potential consequences of unfettered science and technology in areas like genetic engineering, germ warfare, global warming, nuclear power and the proliferation of nuclear arms. Tension between science and the public has thrown up new barriers to research involving deadly pathogens, stem cells and human cloning. Some of the doubts about science began with the environmental movement in the 1960s."

I believe the authors are right that science cannot be viewed in a vacuum. Advances in science must be viewed in the context of a larger society. Asking questions about how and when science should advance involves issues of theology and philosophy. Employing scientific advances for the benefit of society requires knowledge of political science, sociology and psychology.

Consider the relationship between science and my own field, law. Often advances in science and technology precede systems of law that address those advances. In recent years, we've seen startling advances in biotechnology, including the ability to clone animals. But when legal questions arise, courts and lawmakers have been forced to apply a legal framework that did not contemplate such advances. For example, when writing the seminal treatise on early property law in the 1700s - a book that still influences our thinking today - Sir William Blackstone never contemplated the ability to identify a genetic code, let alone patent it. Nor did Blackstone consider property issues associated with genetically engineered crops, with the potential of causing as much harm as good. Lord Mansfield, the English jurist who is called the father of contract law, never contemplated contract issues as diverse as the world-wide licensing of the rights to technology, nor contracts for surrogate parenthood. The drafters of the Uniform Commercial Code, designed to regulate commerce among the states, never contemplated sales over the Internet. And, advances in medical science in relating and prolonging human life raise new legal issues that Blackstone, Mansfield and others could never have imagined.

In short, advances in science have outpaced the law and legal systems have been scrabbling (often unartfully) to keep up. Similarly, advances in science have often outpaced other institutions in our society: government, organized religion, educational institutions, social welfare systems, and sometimes business. Each struggle with the proper response to rapidly advances in science.

The next generation of able scientists needs a background not only in the natural sciences, but also in the social sciences and humanities. In doing so, they will be able not only to advance science, but to understand when such advances are timely and in the broader interest of the world. Likewise, they'll have the knowledge to manage the advances in science as well as political, legal and economic systems, to ensure that science is employed to the common good.

At Augustana College, our science majors complete a broad general education curriculum designed to help them see science within a larger context. First-year students take courses in an integrated program called "Logos: Discourse and Discovery in the Sciences." These courses focus on how science has developed through history, how science has been understood and practiced in particular historical moments, and how we are affected today by the achievements of science. Course titles include Evolution of Scientific Principles, The Dialogue between Theology and Science, The Mathematical Dimension of Science, Great Controversies in Science, Science and Literature, and Science and Values. Upper level courses such as Medical Ethics and History and Philosophy of Science build upon this base. Many science majors choose a double major or a minor in one of the humanities, social sciences or arts.

The Science Times section identifies the 25 most enduring questions in science. Many are factual questions, such as, "How does the brain work?" "What is gravity, really?" "What came before the Big Bang?" Others concern the role of science in a larger context: "Is war our biological destiny", "Could we live forever" "Can robots ever become conscious?" "Could science prove there is a God?" "How much nature is enough?" "Is evolution truly random?" "Are men necessary? Are women?" These are some of the great issues examined in liberal arts colleges like Augustana. Students who gain a broad, inter-disciplinary education will be best at addressing these problems.

My second point concerns application of the sciences to real-world problems. I submit that doing so requires the kind of critical thinking that develops through a liberal arts education. An integral part of critical and creative thinking is learning to ask the appropriate, probing questions. Equally important is having the courage to do so. What can happen when people fail to ask the proper question and engage in critical thinking?

Consider the space shuttle tragedy earlier this year. NASA transcripts reveal a debate between flight controllers for the space shuttle Columbia. Flight engineer Don McCormack, a member of the team, started to analyze the consequences of a piece of foam hitting the wing. Transcripts show that he said, "We're talking about looking at what you can do in the event we really have some damage there." The team leader cut off critical analysis. She interrupted, saying, "I hope we had good flight rationale" for letting the shuttle take off if there was such a risk. McCormack tried again. He said that on a previous flight there was a similar foam strike, and "we saw some fairly significant damage." The supervisor again refused to engage in critical thinking and creative problem solving. Incredibly, she said that a foam strike is "really not a factor during the flight 'cause there isn't much we can do about it." The team might have been able to assess the damage through spy satellite photos and explore plans to manage the risk, but those efforts were sidetracked. That was a fatal and tragic error.

Application of better critical thinking skills might have helped avert this disaster. A powerful symbol for me in describing the process of critical thinking is a crystal. Each facet reflects light in a different way. When one holds a crystal or prism up to the light, it captures the light and breaks it down into its component parts. The nation's finest leaders -its and best scientists and engineers--know how to turn the crystal. They know how to shed light on problems from different angles. An integral part of critical and creative thinking is learning to ask the right probing questions. Equally important is having the courage to do so. An education in the liberal arts and sciences is all about "turning the crystal".

The final reason that liberal arts colleges have a special place in preparing future scientists is that they offer personalized education. Of course, liberal arts colleges are known for their small class sizes and faculty who view their role as teacher-scholars, not as scholars who must teach. In the area of sciences, its faculty members who supervise labs, not graduate assistants. Most importantly, when faculty member conduct research, they use undergraduate students to assist, often as co-researchers. Universities, of course, typically reserve the privilege working with a faculty member on research projects for graduate students. At Augustana, when they're not helping with a professor's research, students often conduct research of their own, under the guidance of a professor. This enables students to gain valuable experience to give them a head start in graduate school or in government or industry. Last summer, students from Augustana did research in many locations, including the Argonne National Lab in Idaho and the Island of Dominica. Liberal arts colleges are aggressive in giving undergraduates the perks universities often reserve for graduate students - clinical internships, research internships and other educational internships. I believe that these opportunities are why the sciences are so popular at Augustana.

Of course, what is best for science students about a small residential liberal arts college, applies to all students - the opportunity to participate in a living, learning community with a group of like-minded individuals, all committed to growing in body, mind and spirit.

Oliver Wendell homes made two observations, both of which I believe apply to science education at liberal arts colleges. First, he observed, "a mind stretched by a new idea never returns it its original form" A liberal arts education encourages future scientists and engineers to leave their comfort zone. But broadening student horizons is not enough. Holmes also observed that "many new ideas grow better when transplanted into another mind than in the one where they sprang up" Each of us has the ability to create new ideas. We work hard to help science students "turn the crystal" to advance knowledge. We must help our future students gain the courage to ask the impertinent questions so science can better our lives.

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