KEYNOTE ADDRESS BY DR. G. WAYNE CLOUGH
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"Master's Education in the Sciences and Mathematics:
Its Value, Importance, and Growth"
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It is a pleasure to be here and speak on behalf of academe about the emerging professional master's degree in science and mathematics. Georgia Tech is fortunate to have four very successful professional master's degrees in the sciences, and I am pleased to be joined by Andy Smith, our Associate Dean of Sciences who has responsibility for their development, and Jung Choi, associate professor in our School of Biology, who is the faculty coordinator for our professional M.S. in bioinformatics. You will be hearing more about that program from Jung Choi after the break.

The idea of a professional master's degree is not new. Disciplines from business administration to engineering to architecture have had them for years and their value is acknowledged. Data from the National Center for Education Statistics show that between 1984 and 2000 the number of professional master's degrees awarded annually increased from 271,000 to 366,000. During the same time, the number of traditional master's degrees in the sciences remained flat at 14,000.

Why the big difference? Engineering and business have traditionally viewed the master's degree very differently than the sciences. In engineering and business, the MS and MBA degrees are seen as having value in and of themselves, and students who obtain them are rewarded with salaries above that of the BS level. Students can readily stop out at the master's level and go to work, but easily return for a Ph.D. I stand before you as such an example. After completing my M.S. degree at Georgia Tech, I worked for two years before going on to U.C. Berkeley to obtain my Ph.D. This worked well for me, and the flexibility it offered was important in my being able to advance my career.

In the sciences, however, the master's has traditionally not been viewed as an end in itself, but rather as a consolation prize to those who began a Ph.D. but for one reason or another did not finish. This master's degree was not valued by either those who awarded it or those who received it. This significant contrast with engineering and business explains the large disparity in numbers of degrees granted.

The low number of master's degrees in science is a matter of national concern because the U.S. lags its global competitors in producing science and technology graduates. Also, there remains a wide gap in numbers of women and minorities taking science graduate studies. The situation with the master's degree in the sciences is a sticking point in making progress on these stubborn issues.

The nature of the master's degree in the sciences began to be discussed by members of the academic community in the late 1980s. In 1993 the Council of Graduate Studies, followed by COSEPUP in 1995, noted that there was a dangerous disconnect between science education and the career path of many students at a time when the nation needed many more technologically educated people in the work force.

This discussion led to growing interest in an approach that would open a new window on the world for the master's in the sciences. However, in order for the science community in academe to embrace professional master's degrees, ground had to be plowed. Faculty had to be persuaded that science could prepare students for other types of careers with the same level of rigor and integrity as the Ph.D. track. They had to be convinced that these programs would attract quality students and that there was a market in business and industry for them. And they had to be persuaded that the benefits to their faculty and academic units would justify the cost. Finally, there was some fear that these new professional degrees would compete with or undermine the Ph.D. track.

In the case of each of these concerns, there was ample evidence from associated fields like engineering that they were not significant, or could be overcome with relatively little effort. With the growing national interest in the option of a professional science masters degree, a number of universities responded to the challenge.

My colleagues in the College of Sciences at Georgia Tech began questioning the traditional mindset in the mid 1990s. First, we found we had a significant number of bright students who were interested in science and math, but did not want a career in academe. And they were not convinced that they would get what they needed by beginning a Ph.D. program, then taking the off-ramp to a conventional master's degree.

Second, we became convinced that as technology became more ubiquitous in virtually every sphere of life, there was a need for a stronger knowledge base of science and math in the corporate and policy-making arenas. Corporate demand was increasing for employees with higher-level science and math skills, but not conventional PhDs. Instead of a PhD researcher who discovers new knowledge, employers were looking for someone with the skills to make competent use of those new discoveries. Others wanted someone with a mix of skills, rather than a vast amount of knowledge in one narrow specialty. In the policy arena it was clear decisions were being made on life-altering issues without an appropriate level of scientific input. Given that we have to make critical decisions on matters like global warming and stem cell research, why should lawyers or other non-science educated professionals assume the role of decision-maker?

So we began to think about how to structure master's degrees to fit these needs. We hosted a workshop to explore ideas, and we invited people from other universities and from industry. One of those people was Sheila Tobias, and that was the start of a wonderful relationship between Georgia Tech and the Sloan Foundation. The very first Sloan grant for a professional master's degree program was made to the College of Sciences at Georgia Tech in the summer of 1997, and we began our first program that fall. We now have four professional science master's degrees, which the Sloan Foundation has supported.

Each time we assessed the potential for a particular professional science master's degree program, we asked ourselves four questions. First, will the whole be better than the sum of the parts? In other words, will the concepts, courses and faculty that we gather together for this program mesh together to create a dynamic, new entity, or will we just end up with a bunch of disconnected pieces?

Second, we ask whether our faculty have both the expertise and the enthusiasm. This is not the place for a university to enter a totally new field – most of the expertise you need for the program should be out there on your campus somewhere. We also look for a reasonable number of existing courses that we can use as building blocks. The faculty who have the expertise also have to be willing and even excited about doing this kind of teaching. While the work for faculty in professional degree programs includes elements of traditional research, it is also focused towards supervising practicums and internships.

These degree programs are also typically interdisciplinary. At Georgia Tech, ours generally involve three different academic units collaborating in the same program, bringing together faculty who are willing to work in that kind of setting. Fortunately we have a strong culture supporting interdisciplinary work. In fact, we encourage it as well as a certain degree of risk taking. It is perfectly all right to take on an initiative with a risk if it has a high payoff. And in this environment it is okay to fail. By setting afloat enough good ideas, some will take, while a few might not succeed. In both cases, we feel the outcome is satisfactory as long as over the long haul we have more successes than failures.

The third question is whether there is clear need and strong support from business and industry for the program. And we define the word "support" in very tangible terms –

letters that put it in writing, financial support or in-kind contributions of equipment, a willingness to offer internships or clinical experience to our students, a willingness to serve on advisory committees. We are looking for concrete support that has substance to it, and if industry is willing to give it, then we know the demand is there for the kind of graduates the program will produce.

Then fourth, is student interest strong enough not only to pay tuition, but also to pay a higher differential? The traditional model for graduate students in the sciences is to pay no tuition in exchange for assisting faculty with research or teaching. In contrast, professional master's degree programs are closer to the MBA model. Students may have fellowships or assistantships, but many pay the bulk of the cost of their education themselves. At Georgia Tech, students in our professional science master's programs generally pay 1.6 times the regular tuition, bringing these programs closer to being self-supporting. The extra funding funds special labs and allows us to give strong support in career placement to our graduates.

If we have this kind of strong interest and commitment both from students and from industry, then we know the program meets a very real demand and will succeed.

There are several other characteristics that describe Georgia Tech's professional master's programs. First, we call them "focused" professional science master's degrees, because they are designed to address specific niches in the workforce. And because they are focused on niche workforce needs, they are designed to be flexible, so that they can readily adapt to change. They also involve feedback loops or communication mechanisms to and from employers, which are essential to keeping the programs relevant to the niches they serve.

These programs take about two years for students to complete. More than two years is too long, but significantly less than two years does not provide enough time for student-faculty engagement and is too short to accommodate internships.

Georgia Tech received the first Sloan Foundation grant for professional science master's degrees in the summer of 1997 and immediately began our first program, accepting the first students that fall. This program offers a degree in human-computer interaction, and it addresses the intersection where people meet computers. Students study the human and psychological issues involved in the design, implementation, and evaluation of computer interfaces.

It is a partnership of our College of Computing, the School of Psychology in the College of Sciences, and the School of Literature, Communication, and Culture in the Ivan Allen

College of Liberal Arts. We have 55 students enrolled in this program this fall, and more than 50 alumni are working for companies like IBM, Dell, Panasonic, and Siemens Research. A large percentage of the students in this program are women, in contrast to the fading percentage of women participating in traditional computer science programs.

In the fall of 1999 we began our second focused professional master's in bioinformatics, which addresses the mathematical and computer issues and models involved in working with large bioscience datasets. This program is a joint effort of our Schools of Biology and Mathematics in the College of Sciences and the College of Computing. It has 35 students enrolled this fall, and recent graduates are working at Los Alamos National Labs, GlaxoSmithKline, Toronto Children's Hospital, and the Vanderbilt Genome Center. You will hear more about it from Jung Choi.

In the fall of 2000 we began our third professional degree program in quantitative computational finance, which provides students with the skills they need for the increasingly complex computational analysis and mathematical models of the financial world. You might call it "financial engineering." This program is sponsored by the College of Management, the School of Mathematics in the College of Sciences, and the School of Industrial and Systems Engineering in the College of Engineering. There are 46 students enrolled this fall, and its graduates work at ING Investment Management, Cinergy, Kensington Partners, Silverback Asset Management, and the Atlanta Federal Reserve Bank.

Our newest degree is in prosthetics and orthotics, and it is the only program of its kind in the world. We do not expect it to have large enrollments, but rather to attract students with a bent towards helping those who are disabled to live a full life. We began it last fall with 5 students, and enrollment this fall is up to 14. This program involves the School of Applied Physiology, the School of Electrical Engineering, and the School of Biomedical Engineering, and it is focused on developing sophisticated prosthetics for the lower limbs that allow maximum comfort, balance, and mobility for their wearers. As you might expect, students in this program have a required clinical practicum.

All of these programs have specialized labs, and our industrial partners often help us by donating equipment. The prosthetics and orthotics lab, for example, contains several hundred thousand dollars worth of equipment donated by industry. The lab for the quantitative computational finance program especially draws rave reviews from students, because it includes a working model of a stock market trading floor. These custom-designed labs plus other benefits like specialized career services, are part of the reason our students are willing to pay the tuition differential – you have to pay more, but you also get more in return.

These four degree programs are working well, so well we are looking at ideas for additional programs. Possibilities include degrees in air quality and environmental measurement that would be offered jointly by the School of Earth and Atmospheric Sciences and the School of Civil and Environmental Engineering. We are also looking at a possible degree program in zoo and conservation management that would bring together the School of Psychology, the College of Management, the College of Architecture, and the School of Public Policy.

Of course Georgia Tech is not alone in its efforts to develop sound professional science masters degree programs. Today the Sloan Foundation has provided funding to nearly 40 universities to establish such programs, and 77 now are working in these institutions. Other universities have developed such programs on their own including Northwestern, Columbia, University of Chicago, and Carnegie Mellon among others. Also the Keck Foundation has funded the establishment of an innovative professional science masters program in the biotechnology area. This program has excited national interest.

I serve on the President's Council of Advisors on Science and Technology, which is known as PCAST, and on the executive committee of the U.S. Council on Competitiveness. Both of these groups are optimistic about the potential of professional master's degrees in the sciences and what they might do to increase the number of U.S. citizens, particularly women and minorities into science based careers. In fact, the Sloan Foundation gave the Council on Competitiveness a two-year grant in July for an awareness campaign on the importance of these degrees.

These two organizations take a big-picture view of science and technology, and of the ability of the United States to be a leader in a competitive global economy based on technology. They have been looking with concern – some might even say alarm – at the declining number of students who are seeking bachelor's degrees, advanced degrees, and ultimately careers in science and technology. It is exciting to see how research in the life sciences has generated new discoveries like mapping the human genome, for example, but we now need a skilled technological workforce in the nation's biotechnology companies who know how to use those discoveries.

Part of the dynamics in the decline of students in science and technology is the shift in the composition of our national workforce to include more women and more minorities – two groups for whom the sciences have traditionally held very little appeal. The science and technology workforce remains predominantly white and predominantly male, and it is increasingly out of step with the demographic dynamics of the nation.

As the number of American graduate students in science and engineering declined over the past decade or two, we filled the gaps at our universities and in our workforce with international talent, attracting students from around the world to our graduate programs, and keeping them here with jobs that paid well. That worked for a while, but it is becoming increasingly obvious that it cannot be considered a permanent solution.

More foreign universities are beginning to offer quality advanced degree programs, and we are seeing a corresponding decline in the number of international students who come to the United States for advanced degrees in science and engineering. Of those who do come, an increasing number are returning home after completing their education, lured by the high-tech jobs that are being created in countries like India, China, and the Philippines.

For PCAST and the Council on Competitiveness, the professional science master's degrees offer an innovative alternative to the status quo. These degree programs broaden the appeal of science and math to nontraditional constituencies. They are attracting women and minorities at a higher rate than traditional graduate programs, and 84 percent of the students who populate them are American citizens.

The professional science master's degrees have clearly broadened the appeal of the sciences and math for students. And as these students move into the workforce, they will strengthen the perception that the sciences have a contribution to make in the corporate world and the world of public policy and decision-making. That, in turn, will help to generate faculty interest and drive enrollment growth back on the campuses of the universities that offer these programs.

Technology is becoming ever more ubiquitous in our lives, and it is clear that technology can help with global challenges like preserving the environment while simultaneously generating economic development. The economic prosperity of our nation is also increasingly dependent on innovation. Most sectors of society, from corporate boardrooms to the halls of government need a better understanding of science and technology and a workforce that knows how it can be used. The time is ripe for the emergence of professional science master's degrees, and they can make a real difference.