Women in Science: Opportunities in a Changing Landscape

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Foreword

Bryn Mawr College chose to organize this symposium for a number of reasons. It has always been the mission of this College — and this harkens back to the early days of M. Carey Thomas and to her debates with the President of Harvard — to challenge young women to excel in all fields of study. Although I am a scholar of the humanities, educated first in a women's college and indeed quite prejudiced about the continuing importance of the humanities, it is clear to me that today and in today's world, one of the truly distinctive contributions of Bryn Mawr and of other women's colleges is in the areas of science and mathematics.

With our particular focus on the education of women, these institutions have done an exceptional job of preparing students for advanced education or careers in science, engineering and technology. In addition to high expectations, women's colleges offer their students multiple examples of women who have succeeded in science. I am so proud to say we have a wonderful cohort of women faculty members in our science departments, in our laboratories and among our graduates. As a result, an unusually high proportion of our students major in science and mathematics, and they go on to pursue advanced degrees in these fields at high rates as well. Our record demonstrates that women can be engaged in science, counter to arguments that women are under-represented because they are not interested or do not like it. At Bryn Mawr, women certainly do like it, and we move our students forward in science in substantial numbers and with great success.

While we are justly proud of these facts, they highlight the degree to which girls and young women in general do not pursue these fields. In college, where women are in the majority, potential female scientists and engineers continue to be under-represented, and in some fields the situation is getting worse. The figures in computer science, for example, are particularly troubling. In 1984 when the field was relatively new, women earned 37 percent of undergraduate degrees. By 1999 the number had dropped to less than 20 percent. This very problematic development was recently cited by Dr. Rita Colwell, National Science Foundation Director, as a cause for particular concern. As a community of educators we need to do more to improve this situation and must concern ourselves with both ends of the pipeline.

We are, of course, concerned about the careers of our graduates, and in that regard, the status of women in the science, engineering and technology workplace also must improve. Even with the bursting of the high tech balloon, there is little question that this arena will be central to the future growth of the American economy, indeed the global economy.

According to a recent report by the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology (2000), leaders in many fields are warning of a critical shortage of skilled American workers in these areas. The report pointed out that this shortage is due in large part to a national failure to give much of our population – women and minorities in particular – appropriate educational opportunities and encouragement in science, engineering and technology, and a similar failure to bring them into the workforce, and to retain them. The United States cannot afford to disregard the talent and potential contributions of women, half our population, in science and technology. Although there has been progress in many areas over the past 30 years, it is still the norm to find us underrepresented.

You know better than I that there is no single or simple solution to these problems. Indeed most of you have been thinking about them much longer than I have. I hope the *Proceedings* of this conference can enrich our understanding of the continuous and interrelated worlds of the classroom and the workplace, and explore some possible ways we might proceed individually, institutionally and collectively to improve the situation.

Nancy J. Vickers,
President, Bryn Mawr College

Women in Science — Where Are We Now?

INTRODUCTION

JILL SIDEMAN, Vice President and Director, CH2M HILL, and President, Association of Women in Science

I graduated with my Ph.D. from Bryn Mawr with Dr. George Zimmerman, in 1965. I would like to give you a picture of what it was like to write a thesis in 1965. There weren't any computers. At least the computers that we had were extremely large and unwieldy and not something that you could carry around. So my entire thesis was first handwritten by me and then typed by my long-suffering mother-in-law. Every page had to be typed with carbon paper and if you made a mistake you had to go back and try to white it out or otherwise correct the mistake. All the graphics were hand-drawn by me, and you can imagine what they looked like.

I would like to contrast for you what it would be like to write a thesis today. Today you have a computer. Probably many of you have your own personal laptops or other computers. You have programs that allow you to generate graphics easily. It is very simple to correct or change a word today. Think about the difference between 1965 and now just in that level of technology alone.

I would now like you to think about the position of women in science, engineering and technology then and now. In 1965 there were not that many women going into the field that I was in — physical chemistry and, in particular, quantum mechanics. It is not that much different now. There were few women in the field in 1965 and there are still few women in the field. I work in industry. I work for heavy industry, high-tech industry, and I work in engineering. And I can tell you that there are still very few women in these fields. Women constitute 45 percent of the workforce in America but only 12 percent in science and engineering jobs in business and industry. That is a disgrace.

I would submit that we must do something to make that change. I am not going to give you a lot of statistics about industry or business, nor about academia, which I would submit is really no better than industry. In fact in some ways, academia is worse than industry in terms of promoting women to the top — that is, to full professor. Less than 10 percent of full professors in the sciences today are women. But women have consistently been earning more than a quarter of the Ph.D.s in science for 30 years. Why do we still have only 10 percent of full professors who are women?

It is a real problem that is facing us and I, coming from industry, can tell you that industry is dying to find good women and minorities. Many industries have learned that diversity is critical to their success and their competitiveness. This is not just, "it's the right thing to do." It is a bottom-line issue. In my firm, which is a large-scale $2 billion-a-year company with 140 offices around the world, if we cannot field a team of people to go talk to a client who can think like that client, look like that client and act like that client, we do not get the work. We have lost jobs because we were not diverse enough. And I do not mean just diversity in gender or race, but in thought process, in understanding of cultures, in all of the ways that you can think of diversity. It is a bottom-line issue for industry. If we educated and had been continuing in science and engineering the women and minorities who could potentially be doing it, we would not have a workforce shortage in this country today.

The first National Science Foundation statistical report on women in engineering, science and technology came out in 1982. So we have been recognizing and studying this problem for 20 years. It still is not solved. It still is not changing as rapidly as it needs to change. I am so glad to see all of you here because I think it is very exciting. Hopefully we will be able to come up with some good solutions that we can all begin to implement.

I want to just make a pitch for the report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology (*Land of Plenty*, 2000). This report focuses on four times in life when we lose women and minorities to the fields of science and engineering. The first is entry to middle school, the second is in late high school, the third is in college and graduate school, and the fourth, I am sorry to say, is in professional life, where women still do not advance in proportion to their education. The Commission had a few recommendations, one of which I will talk about tomorrow after Connie Morella speaks.

We had only a few recommendations because we wanted to try to get them implemented and not have them lost in a morass of 50 or 60 recommendations. So we only have about six or seven recommendations and there is, I am happy to say, a program to implement these going on right now, which I will tell you about tomorrow. I also want to recommend the recent report called *Balancing the Equation, Where are Women and Girls in Science, Engineering and Technology?* done by the National Council for Research on Women (2001).

I really encourage you all to participate actively in the workshops and try to think when you are doing it about what you can do that will actively help to make change for girls and women in science, mathematics, engineering, and technology.

CATHERINE DIDION, Executive Director, Association of Women in Science (Panel Moderator)

What we’re talking about today is where women are now in science, technology, engineering and mathematics (STEM) fields. And I think we must consider the role that women have in science and technology, and the consequences of that role in terms of what happens to this nation and to the world. I feel very strongly that we have to look at what we can do to integrate more women more fully into the seats of power, not only in science, but in policy as well. The panel will also try to look at where are we going. What is progress for women in science and technology?

SUSAN GRAHAM, Director of New Business Development, Adhesives and Sealants, Rohm and Haas

I guess there are two ways to look at Sue Graham's career. You can either say I have really progressed and moved on to other things, or you could say I cannot hold a job. I will leave that discussion up to you. I have a Ph.D. in high-vacuum surface physics and thought when I left the University of Pittsburgh that what I wanted to do was be in the lab the rest of my life. I was good at that and I really enjoyed it, but I went into industry and found out that what I really liked was being with people. So I did some other things, spent time in sales, ended up running a business, and now, as of a year ago, do mergers and acquisitions and portfolio management for our adhesives and sealants business — which I knew nothing about a year ago. The reason I tell you all of that is I think it is really important that educators tell people to figure out what they like — I personally like to be on the steep part of the learning curve — and then go do what you like. If it happens to be in science and mathematics, so much the better.

The other thing is we must tell people to surround themselves with friends and family that are supportive of their pursuit of what they love. In this multiple career that I have created, I have lived in Columbus, Ohio; Fairfield, Connecticut; Bridgewater, New Jersey; Chattanooga, Tennessee; Raleigh/Durham, North Carolina; and now downtown Philadelphia. But I have been married to the same man all that time, who has had the same job. He covers the entire East Coast for a large chemical company, so we have been — I have been — very fortunate to be able to move around and do different things. But you have got to have people around you who are flexible and supportive.

CATHERINE DIDION

Thank you Susan. I think one of the questions we'll have to raise later is what are some of the safe environments in which you can figure out what you like to do. Particularly for graduate students, there's always this fear, "If I share with my adviser what I'm really thinking, what are the repercussions?" It would be a wonderful thing for discussion to explore some of the ways that we could help figure out what we like to do.

MARIA-LUISA MACCECCHINI, Founder and former CEO, Annovis Inc.

Many women in science who move into industry never planned to do so. That is in some ways true for me also. I studied in Switzerland, and there was only zoology then and it was pretty miserable. I decided zoology was not what I wanted to do and the United States had much better science, so I came to Rockefeller University. I really wanted to be a professor, and like Sue, I was good in the lab. I would mix my stuff and it kind of worked and you got publications. Then I got bored with test tubes. I decided I liked people, too. But I also wanted to develop a product: I wanted to have a drug.

So I went to a pharmaceutical company as an entry-level scientist, and I did really well. After six years I was running a group of 35 people as manager of molecular biology (whatever that was). And I said to myself, "I'm never going to develop a product here. It is so bureaucratic and things are so slow." I think we were talking about the glass ceiling then, too. But basically it occurred to me it was going to take me 30 years to make it to VP of R&D. So I went to work for a much smaller company. I was not developing a product there either, but I got into business development and sales, which really gave me a hands-on M.B.A. That was my decision: instead of getting an M.B.A. to run a company, I was going to kind of do a little bit of business-type work. And it worked out all right.

Then I started my own company because we were going to develop drugs. Well nine years after starting the company, we are in the clinic with two drugs. We have one in the clinic for epilepsy and we have one in the clinic for addiction. But we are not done yet.

If I can go back to what Jill Sideman was saying, the interesting thing is that the problem of women in science and/or business is twofold. One is there are not any women, especially at the highest levels. If I want to hire a woman as a VP of R&D, I cannot find her. I really cannot. I do have two women who work for me: one is VP of Business Development and one is VP of Sales. Not R&D: they just do not exist. The same is true for minorities. But let me say that two ethnic groups seem to be doing something right, and those are the Chinese and South Asians. There are not very many chemists in the first place, and there are not that many biologists who do molecular stuff, so when we look for an entry-level person with a Ph.D. or a Sc.D., we get a lot of Chinese and Indian applicants, and they are well trained.

So it seems like even though there is a ceiling someplace, if you just hang in there and work, since there is such a shortage of people, you are going to get there. But the difficulty is first to get a woman into the door and then have her be consistent enough. And I do not mean this in a negative way. It is tough. You will be turned down, and people will make snide remarks, and you will go to a panel and only the guys talk and you will not be invited. And that is reality. So the only way you can deal with it is just say, “OK, I’ll try again.” Just don’t give up: “I’ll try again.”

The reason I started my own company really was that no matter what job I had, it would have taken me forever to become CEO, and I probably would have died before I became CEO of the company for which I was working. So you go around the existing structure and you start your own. And the problem then, of course, is a totally different one. You have to raise money and then you have a credibility issue. Bankers don’t like women, either. But it is doable and I think that if we can tell women — or minorities — that if they like something, if they have a dream, they should just go for it. Martin Luther King did not say “I have a budget,” he said “I have a dream.” And so if you just follow your dream you are going to get there sooner or later, but the reality is that it is not linear. It absolutely is not linear.

If I had stayed in my first job, maybe I would be VP R&D by now, but it would be boring and it would have been a struggle with a lot of politics against a lot of other people that wanted that job. Plus with all the mergers taking place, you have more politics that come on board. So I think I did the right thing by going into my own company. And you really have to believe that you can do it. And if people tell you not to do it, just ignore them.

CATHERINE DIDION

Maria-Luisa, your comments raise some interesting questions about the nontechnical skills that you realized you were able to get — how they contribute to having the knowledge and experience necessary to start your own company, and the possible arenas in which women can learn these skills.

ANNE M. THOMPSON, Ph.D. '78, Astrophysicist, Atmpospheric Chemistry and Dynamics Branch, NASA Goddard Space Flight Center

I feel very privileged to be part of this symposium. There were a few points that I wanted to make that I hope will address the multiple sectors that our handcount showed are here in the group today, and at the same time answer some of the questions that Kitty Didion asked us to speak to.

The first thing that I want to do, though, is clarify my job title, and this is revealing in itself. Astrophysicist is an arcane classification by NASA, which is a bureaucracy. Although Goddard Space Flight Center, where I work, employs several Bryn Mawr astrophysicists, my colleagues and I study the earth ozone from satellites and from aircraft and ground-based instruments. So really, the label that should go on those in my group is geoscientist. And in that respect a lot of the perspectives about career and career ladder that I will offer will be similar to those of Professor Grew, because she is actually a geologist. Furthermore, our promotion and career ladders are probably somewhat similar in that we have both been promoted on the basis of publish-or-perish research, funding records and service. Professor Grew's experience has been in teaching and education, and mine has been in managing, directing and running projects for NASA's missions in science and for the American people. So my perspective is that of a traditional research career in the government sector. And I want to mention a couple of aspects that respond to Kitty Didion's charge to look at where we are today.

If you have listened to what other panelists have said and you piece them together, the buzzword is interdisciplinary. And the sort of work that I do, a chemist turned into a geoscientist, is quintessentially interdisciplinary. Thus an issue for our panel to think about is how does the academy, still very disciplinary in its divisions, prepare us for jobs in the real world that bring to bear our most rigorous scientific training, but with the need to be flexible and interdisciplinary in our thinking? I have found that being able to do this does actually help propel one forward, and is one reason that my work has been so exciting.

I am actually more excited in the middle of my career about what I do than I was when I left graduate school and when I was a postdoc. It is because we keep addressing new problems. The ozone hole, which was the buzzword of 10 years ago, is now replaced by ozone smog concerns, which are the sort that I study. And if you do interdisciplinary work and keep redirecting it to new problems that emerge, you stay at the cutting edge. Your career continues to move, always upward, but with zigzags because we have all had these nonlinear careers. This is a very important thing to realize.

Also increasing in our vocabulary for doing science and technology are international aspects of the work. Those of us doing geosciences come face to face with this because we collectively own the planet, and the atmosphere moves across national and international borders. I have felt very fortunate that the projects that I have done have taken me into many countries. I was in South Africa last week working with graduate students who have taken data with me jointly in projects throughout the southern hemisphere tropics. So I think “international, interdisciplinary, evolving” are good descriptions of where we are.

I want to say a few things about service in the government. And the first two relate to policy work in a more general aspect than just being in the government, because there are a lot of policy organizations that scientists join that are not strictly governmental. One is that the opportunity and the challenge to keep modifying the problems that one solves and re-addressing research to meet these problems is always in your face when you are working for the public or quasi-public sector. This presents opportunities; it presents challenges. You are not simply allowed always to do exactly what you are enjoying doing. I frequently have had multiple projects and I have published simultaneously in several areas. But some drop out of favor or out of funding, and others come to the fore. And it is necessary to stay flexible in that regard. If you work for the government you are going to be faced with doing that. It is an opportunity and a challenge.

One of the best parts about this sort of work, though, is that we are often connected to very hot issues. If you are doing ozone for example, you will be entrained into writing ozone assessments that guide policy-makers. I have been a contributor to the intergovernmental documents on climate change. So those career opportunities and opportunities to serve have been pluses in government work.

There is another factor that educators and students might think about and that is there are multiple paths to advancement within the government. There are more policy or management of policy tracks. The track that I am in is still essentially a quasi-academic research track. But there are multiple ways one can advance within the government sector when one is trying to deal with the complexity of life’s challenges and issues of geographic location. The last aspect of government service, which I found has been very positive, is that our promotion system and our pay scales are pretty black-and-white and totally public. Thus pay equity is less of an issue when you know what the person next to you is making and what you have to do to get to the same level.

One of the challenges that we face, and we have already talked about this as a potential issue for panels to address, is that the government is downsizing. The agency for which I work has shrunk 30 percent in the past 10 years. It is going to be much harder to advance in government service for people coming out of school now. And yet the sort of environmental issues that we study and address are going to need to be solved by our society. I can see from this symposium that Bryn Mawr is already addressing these issues with our very coming together and recognizes that it has a very special role to play in bringing students, educators, and the private and public sectors together.

I guess that maybe the advice I would give to students would be, first, never relax your basic scientific training and instincts. I have seen bad data proliferate and I have seen spacecraft miss their target because people did not stop and question what they were told. Second, stay alert, informed and ready to reinvent yourself as trends and needs change. I was a chemist. I am now a geoscientist. I can affiliate now comfortably within engineering schools, and that would have horrified me as a chemistry student and it might have horrified my professors. And finally, I heard somebody else say already, follow your heart, find your passion and have some fun.

CATHERINE DIDION

I would love to have some discussion later on about how one does manage zigs and zags in careers because I think we've all experienced them.

PRISCILLA PERKINS GREW '62, Professor of Geosciences and Former Vice Chancellor for Research, University of Nebraska

So our topic is, what is the changing landscape in our profession in science? This room — the Great Hall of the M. Carey Thomas Library — is a really wonderful place to have this discussion, for it was created to make women feel that they were in the absolute intellectual elite. The room was modeled after one at Oxford's Wadham College, in part to make women comfortable with the experience and environments of leadership. And one of the things I want to talk about today is how women's colleges have been successful in making women not so afraid to be in the lead, and how we can enable women in other settings to deal with the fears of being at the top. For at the moment, there is a very serious gender gap in the top leadership in science in the universities. If we take a snapshot in time right now and compare it to a snapshot taken four years ago, we would find that there are still comparatively few women in top science leadership positions at the premier, big-time universities. Few women in the really senior positions, the power positions: the chairs of departments, the heads of the big research labs, the scientific leaders in government, the numbers of women in the Academy of Sciences, the Academy of Engineering and so on.

In geosciences, we have certainly made a lot of progress in terms of graduation rates and numbers of degrees earned as undergraduates and graduates in sciences. The year that I got my Ph.D. — 1967 — I was one of four women in the United States who earned a doctorate in geosciences. I had no idea at the time that there were so few of us. With the preparation that I had gotten at Bryn Mawr, I didn't realize that there was anything particularly strange about getting a doctorate in geosciences.

I think one of the biggest contributions we can make is really to help women deal with their fears of being in the lead, their fears of being better than other people in the class. It is a fear that starts in elementary school. It is a fear that is in middle school, and in high school when girls do not want to set themselves apart. They are afraid of being a nerd. They are afraid of being best in class. I see that fear in women in my undergraduate classes at Nebraska. Young women in my classes do not want people to know they got 100 on the test. They just do not want to stand out. And I think in order for women to be competitive at the highest level, in order for them to move into the top levels of the scientific establishment in this country, we are going to have to deal directly with some of these fears.

There was an article in the *Chronicle of Higher Education* in July 2000 by Wendy Williams, an associate professor of human development at Cornell University, called "Women in Academe and the Men Who Derail Them" — a catchy title! In a bit of a different sense than what I want to talk about, it deals with one of these fears. The article is about how women graduate students who are easily able to compete for top-level jobs nonetheless limit their job search to a very limited geographic area because of a personal relationship with a partner, a male who does not want to move. There is a tendency for women to make that kind of adjustment early in their career thinking, OK, I will take this job for one year in kind of — well, we won't say Podunk U., "somewhere in the Midwest," since I come from the Midwest — but I think you know what I mean. They do not take the job that they would have taken if they were able to apply at the national level and so this initial choice, Williams argues, really sets these young women up to not reach the potential promised by their skills and talent. I want to tie this one example to the famous quotation of M. Carey Thomas: "our failures only marry." It is stated slightly differently, but it is a similar issue of having to deal with the fear of loneliness.

I am going to talk about what I think are two major fears that women have. First is fear of loneliness and the second is fear of risk-taking. I think we have to address both of these fears. There's a lot of talk now about President Roosevelt's "freedom from fear" and that we should have a right not to be afraid. I think we all realize that we are not completely free from fear in life, and a woman in a scientific career is not going to be completely free from fear. It is a matter of learning to live with fears, to manage fear, to manage fear productively.

That is what I think we have to work with among minority women, too. I work, for example, with Native American women students, multicultural studies and repatriation of Native American remains. If I were an Omaha woman getting up to speak, what I would first say is I am embarrassed to speak before my elders and I am also embarrassed to speak before those who know more than I do. In some Native American cultures, it is considered bad manners to set yourself apart from others, or to be seen as being superior to others in accomplishments. If you do that, then you are put in a very lonely situation.

I think that fear of such a sphere of loneliness also haunts women going into science careers. They are afraid they are not going to be able to continue a personal relationship, they are afraid of having to lose their friends in high school, they are afraid of not being popular — you name it. This kind of fear of loneliness and isolation covers quite a broad area. They feel they are going to be a nerd, they feel they are going to be somehow set apart in some sort of impersonal science and technology that has no humanity to it.

There are, however, ways to deal with this. An earlier speaker mentioned the image that the woman scientist "does not have a life" and lives in isolation. Certainly there are people like that in any sort of a population, but science today is an extremely social activity. You have got to be able to deal. You have got to be able to work in a research team. You have got to be able to manage graduate students. You have got to be able to put together a coalition of research teams from different universities. If you are the head of a department, you have got to solve all sorts of personnel problems, deal with the dean, deal with the president, sell your budget. So being in science and technology is not in any sense an impersonal thing where you are going to be cut off from the world. In fact if you want to work in science management, you can have just as much personal interaction as you want.

People also do not realize how much socializing there is among scientists, among scientific networks, among administrators. There is an association for everything — university presidents have an association, vice chancellors for research have an association, public utilities commissioners have an association. In fact I am thinking of starting a support group for Native American Graves Protection and Repatriation Act (NAGPRA) Coordinators! I have actually gotten some possible takers on that.

I also think women can cultivate a strategic use of humility that allows for a different style of leadership. I tell women students, OK, you can be a star. Just look at our football star and see how he reacts with the press: humility is the thing. We had this wonderful football coach at Nebraska, Tom Osborne, and every fourth word people say about him is, “He has so much humility.” So here is this superstar, but he conveys also a sense of humility. For women students this example says you do not have to be totally arrogant if you are a leader. In fact the best leaders, our leaders in this audience, are not arrogant individuals.

The second big fear I would say is the fear of taking risks. Of course, any time we make any sort of a decision, we are going to be taking a risk. It is risky to try to succeed; it is risky to be a leader. The risks are criticism, failure, making decisions that change peoples lives. You are going to risk regretting what you have done; you are going to regret making a mistake. You are maybe going to get a bad review on your research proposal. You are going to get your book rejected. You are going to encounter all sorts of things that make you feel inadequate. You are taking a risk by putting anything of yourself outside. I am taking a risk by giving this talk to you because maybe you are saying, “Well she’s just out to lunch, you know?”

So we have to take risks in order to go into science, in order to be scientific leaders, in order to be a department chair, in order to be a college president, in order to be head of a company, in order to be a CEO. You are “it” if something goes wrong. You get the credit if everything is fine and if something goes wrong, then you get blamed for it.

In order to cope with this risk-taking, the key thing is a sense of humor. I would advise anyone just to look at a Hugh Grant movie, one where he is just sort of bumbling along and being totally charming, making one mistake after another, but has a sense of humor. The “Hugh Grant lesson” is not to take things quite so seriously when you make a mistake — to learn from your mistake, but also to forget the bad part and move on. It is a cliché, but you have just got to keep moving on. So, learn to have a sense of humor about your mistakes. You are going to make ones that are really horrible and you are going to have to ask for a lot of forgiveness and you are going to have to accept forgiveness. There is a lot of historical baggage that you just need to leave behind. A mistake often hurts you more than anybody else, and so you do not really have to have a total guilt trip about it.

The antidote to this fear of risk-taking is also to continue to test yourself, continue to try new things. You look at this panel. We have all kind of created unique careers. I think I am the only person in the country who is half-time a full professor in geosciences and half-time Native American Graves Protection Act coordinator. I think there are a lot of people in this room who have unique careers.

I am scared of taking on something new, yes, but then I think, "OK, well I made a bigger jump about two jobs back, that one where I was really scared, and I survived." I remember when I interviewed for the position of vice chancellor for research at Nebraska. I had never done anything like that job before. The chancellor was Graham Spanier, who was at Nebraska before he became president of Penn State. The interview was in his office, and I was trying to do my best. And at the end, he finally just looked me in the eye and said, "Priscilla, can you do this job?" And I just said, "Yes I can," hoping after I said it that I could. But I had the confidence that I knew I could make a real break; I had already taken a jump from pure academia into state government and then state government into directing a state geological survey in a university.

I did not speak at a microphone until 15 years after I left studying in this room. I finished graduate school at Berkeley and took my first teaching job at Boston College. Boston College was a men's Jesuit institution at the time. I taught beginning geology — "rocks for jocks" — including the freshman football team. In fact I still have my notes and at the top it says, "Good morning, my name is Priscilla" — I guess in case I forgot. I was so nervous and self-conscious about public speaking, it took me two weeks to find out from my TA that there was a hearts card game going on in the back row. I hadn't been a TA at Berkeley; I was just going into this cold.

Each time you try something new it takes some of the fear out of risk-taking. That is why I think we must give our women students opportunities to try new projects. That kind of experience is one lesson we can take from the practice of Bryn Mawr and the other women's colleges. These successful 19th-century experiments have produced wonderful women leaders by making them comfortable with their abilities, making them feel they are not going to be lonely as leaders, making them able to take new risks and helping them to convey that experience to other women.

CATHERINE DIDION

Gerhard Sonnert and Gerald Holton of Harvard University echo a lot of what you said about risk-taking. They did a very good book called *Gender in Science Careers: The Project Access Study* (1995), in which they note that one difference between men and women scientists who had won a very prestigious postdoctoral fellowship was that the women had a different view of their own ability and different comfort levels in taking risks.

JANE BUTLER KAHLE, Condit Professor of Science Education, Miami University, and Senior Adviser, Directorate of Education and Human Resources, National Science Foundation

Much of my career has focused on identifying barriers that prevent women's full participation in science as well as what facilitates their achievement in scientific fields. I focus primarily on K-12 education. I am going to talk about K-12 issues and then briefly continue through the postdoc experience.

I was fascinated with Priscilla Grew's comments about speech patterns among Native American women. About 20 years ago, when I had a group of women doctoral students at Purdue University, I called a colleague in the communications department at Purdue to ask that she talk with my students about speech patterns. It was an eye-opening seminar for my doctoral students and for me. My colleague pointed out how many women begin sentences with disclaimers; e.g. "Well, I thought I would say," "I was thinking about," etc. Women tend not to state simply: "This is what I know," "This is what I can do."

Another point that I want to make in preface is that women are not a homogeneous group. There are different gender achievement patterns with Asian Americans, with African Americans, with Latinas and with European Americans. We have to be very explicit, and too often — both in government and in academia — data are generalized, reporting all women as one homogenous group.

What I have experienced over the past 20 years and what I have seen at the national level in the last few years is a very subtle change in what constitutes barriers to girls and women in science, mathematics and engineering, and how those barriers are built or broken in K-12 classrooms. No longer do researchers find evidence of overt sexism nor examples of overt discrimination in mathematics and science education. What one finds now are very subtle differences (what I call covert sexism or discrimination).

Recently, Valerie Lee at the University of Michigan and her colleagues reported on a study of 21 secondary schools, examining what they called "gender-related incidents." They studied single-sex female schools, single-sex male schools, and coed schools. In each school, they observed classes in history, algebra, English, chemistry and one other subject selected by the school. They found similar overall frequencies of "gender-related incidents" in all three types of schools. However, across all three types of schools, the incidents were more common in chemistry classes. Further, as the proportion of males to females rose in favor of males, those incidents became more frequent. Lee reports that "gender-related incidents" are small and so common that they often go unnoticed by the untrained eye. That is, they are subliminal or 'elevator music' in a young woman's education.

In another example, a Canadian researcher tried to figure out why the girls in his middle-school physical science classes, who were doing very well, did not enroll in high-school physics. He identified a barrier that he called "gender lore;" that is, vaguely remembered information from media reports and studies that is widely accepted and believed by adolescents of both sexes (e.g., girls can't do math). His work suggested that the belief and passive acceptance of “gender lore” affected girls’ confidence, their willingness to be risk-takers, and their performance in physics and physical science. Next, he developed a program that challenged “gender lore,” resulting in more girls enrolling in physics.

I find these two studies very important because they suggest, and name, the subtle differences that girls experience in science classrooms. They also suggest new approaches to gender equity. Twenty years ago we focused on providing role models who would motivate girls to become scientists. We sent women scientists into classrooms. However, results were mixed — at best. Then, a grant from the National Science Foundation allowed me to examine the effect of near-age role models; e.g., college undergraduates in lieu of professional scientists. Junior and senior women science majors assisted with laboratories in middle and high schools. My graduate students and I observed and, over and over again, we heard similar conversations. A high school young woman would ask the college student, “Are you really a biology major at Purdue?” “Yes.” “Is it hard?” “Yes.” But the final question was always: “Do you date?” Clearly, young women needed role models with whom they could directly relate.

In thinking about this talk, I revisited a very interesting experiment for retaining girls and women in science by Neil Abraham at Bryn Mawr College. Dr. Abraham developed a program that combined four critical aspects for keeping undergraduate women in science. First, he designed introductory courses with a minimum of prerequisites so that young women who had not taken physics in high school could enroll. The hope was that some of those women would discover that physics was the love of her life or at least one of the loves of her life. Second, he involved students in talking and writing about physics, drawing on their verbal as well as quantitative skills. Third, he used effective pedagogy. For example, because demonstrations and large lectures often seem distracting, inconclusive and very disconnected from laboratory work, he used the same pedagogical approach in lecture as he used in lab. This strategy is very important because on the whole, women have fewer hands-on experiences with scientific equipment. Fourth, he provided research opportunities and internships for students. He assigned one department member to identify research opportunities on campus for first- and second-year students and off-campus opportunities for third- and fourth-year students. Throughout their undergraduate years, the young women practiced what they were learning. He also established faculty apprentice opportunities for students. College funds were used to provide apprenticeships so that students could begin to have some in-depth insights into the doubts, despair and indecision that are a natural part of any faculty member’s life. His program was absolutely fascinating, because it addressed all the barriers that research has identified for recruiting and retaining young women in science.

However, barriers still exist. According to a recent report of the American Association for the Advancement of Science, women scientists still earn 77 cents for every dollar a male scientist earns, a situation that has not changed in 20 years. Further, women full professors, on average, make 14 percent less than male professors do. Real barriers persist in the workplace, whether it is academia or industry, because little progress has been made in accommodating the lifestyles of women. Different patterns of promotion and retention are needed, particularly changes in the accepted tenure pattern. During childbearing years it is difficult to work full-time. Flexible routes to tenure, in terms of productivity and years allowed, are needed. Simply put, academia has not accommodated well to women’s life patterns.

What can be done to overcome persistent barriers? Very briefly let me suggest some radical strategies. In general, women have different entry points into the scientific professions, whether academia, business and industry, or government, than men. It is very important that those entry points be identified and accommodated by promotion and tenure decisions. For example women tend to have longer postdocs, delaying their entry into the tenure track. More women than men follow nontraditional educational paths. We do not have strategies that allow us to reach out to women who are in community colleges or to women who complete their education part-time. There are few scholarships for part-time students (mostly women) in colleges and universities.

We need scholarships and fellowships that go to promising women scientists, mathematicians and engineers who are able to enroll only on a part-time basis. Because many women follow their partner to their initial job, we need to provide graduate women in science, mathematics and engineering with “portable” financial aid, allowing the completion of their education and the initiation of their careers. We might also experiment with pilot programs that guarantee matching graduate school funds to women college juniors who successfully complete a summer research internship. And, we could target financial assistance to programs that allow women students to earn salaries while becoming involved in the scientific community during college. These are a few suggestions that might serve to attract and retain women in scientific and technological fields.

The need for women scientists and engineers is clear. For example, the number of women undergraduates in leading technology institutions between 1987 and 1997 remained essentially the same — the percent of women studying science at Georgia Tech has gone from 23 to 28 percent and at MIT from 32 to 40 percent. If we do not increase the number of women entering the scientific workforce, the need will be met in other ways. Currently, the government has increased the number of visas allotted in technological and scientific fields. Part of the fees for those visas, paid by industry and business, goes to the National Science Foundation to support programs to encourage students to study science and engineering. However, those programs do not focus on barriers for women or minority students.

Even with a dearth of qualified scientists and engineers, as a nation we are not investing in programs and research that address barriers to women in science. For example, the National Science Foundation targets only 5 percent of its education budget towards programs for girls and women. Further, in response to an interview question, none of the candidates for director or the division that administers programs for women and girls replied that additional targeted funds were needed. In other divisions, funds for research or intervention programs for girls and women are extremely limited. Yet, across both public agencies and private foundations, the NSF allotment is the largest targeted fund for women in this country.

Research has established that girls decide to continue studying science — with the option of a scientific or technical career — by grade 5. Further, we know that subject choices in middle and high school either serve to keep the door to a scientific or technical career open and to close it firmly. We cannot wait until college to encourage women to consider science, but women college undergraduates can play important roles in encouraging girls to keep their options open. And teachers as well as parents need to be cognizant of the sexism in a girl's everyday life — from computer software to old-fashion games and toys to TV programs and commercials. The barriers to girls and women have not vanished; they have shifted. We know from research that the accumulated effects of "gender-related incidents" and/or "gender lore" can be as damaging as overt comments. Perhaps, the subtle forms of discrimination are a greater concern, because they are difficult to recognize and, therefore, to address.

Diversity in the Engineering Workforce

William Wulf, President, National Academy of Engineering

INTRODUCTION

MAXINE SAVITZ '58, former Director of Technology Partnerships, Honeywell Corporation, and Member of the National Academy of Engineering and the National Science Board

It is my privilege to introduce Bill Wulf, who is the President of the National Academy of Engineering. I have had the privilege of working with Dr. Wulf for the last six years or so on the governing council of the National Academy of Engineering. In addition to his role as president of NAE, he serves as vice chair of the National Research Council, which is the operating arm of the National Academies. He would like to see more of the women and men here participate on our committees, and might recruit you all to do some work on the studies. Dr. Wulf is another one at this conference who is looking at people in academia, government and industry, and he himself has worked in all three sectors.

Dr. Wulf is currently on leave from the University of Virginia at Charlottesville, where he is an AT&T Professor of Engineering and Applied Sciences. He had been the chair and chief executive of Tartan Laboratories in Pittsburgh; spent time as an assistant director at the National Science Foundation; and early on was professor of computer science at Carnegie Mellon. While he has been at the NAE, he has been a strong supporter of women in engineering and science. The NAE has created Web sites for younger women in K-12 schools and for women in engineering. Through Dr. Wulf's efforts, NAE obtained funding for a summer program for women in engineering. Dr. Wulf has also been a strong supporter of the NRC's Committee on Women in Science and Engineering, led by Dr. Jong-On Hahm (also a participant in this symposium).

One of the things we heard from a lot of speakers today is the importance of having a partner that really supports what you do in order to be successful. Dr. Wulf's wife is Dr. Anita Jones, a well-known member of the University of Virginia's computer science department. She is also the vice chair of the National Science Board, and, under the Clinton Administration, was under secretary for research at the Department of Defense. Bill and Anita cannot quite get their schedules together — when he is in Washington, she is in Charlottesville, but they are managing to be at the same place.

So Bill brings many sorts of experience with him today — professional, personal and practical — to his talk today at this symposium dedicated to the advancement of women in science and technology. So I want to welcome you Bill, and tell you how pleased we are that you came to join us.

KEYNOTE ADDRESS

WILLIAM WULF

The Academy of Sciences — Then and Now

I usually start these talks with a few words about the Academy because I have learned that not everybody knows what it is. There are academies of science and academies of engineering all around the world. They are mostly honorific societies; that is, you cannot join the Royal Society in London or the Academie des Sciences in Paris; you have to be elected by the existing membership. It is considered a very high honor to be so elected.

In the middle of the Civil War, 1863, a group of American scientists got together and decided that we ought to have one of those honorific academies, too. They incorporated what is now a 501(c)3, not-for-profit corporation in the District of Columbia called the National Academy of Sciences. At the time, there was no city government in Washington — the federal government acted as the city government. Consequently, the articles of incorporation of this private corporation were actually a bill passed through Congress and signed by Abraham Lincoln. We make a great big deal of that now, but in the District of Columbia in 1863 it was standard operating procedure. However, what is a big deal is that somebody inserted about 40 words into this otherwise completely boilerplate charter. These 40 words say that the Academy must provide advice to the federal government on any issue of science and technology, and do so whenever asked and without compensation. Thus, this charter has created an entity that is unique in the world: we are both an honorific academy and advisers to the nation.

Let me fast forward to today. What started out as a single entity, the Academy of Science, is now four entities (for their size, the academies are the most complex organization that I have ever seen, so I am going to simplify a little bit). There's the Academy of Sciences, the Academy of Engineering and the Institute of Medicine; you can think of those three as the honorific entities. The fourth organization, the National Research Council, is the operating arm of the honorific societies that conducts the business of providing advice to the nation.

When the government asks us a question, we put together a committee of 10 to 20 people who are absolutely the best in the country, bar none, on whatever the question is. This committee will have no conflicts of interest, and any biases will be carefully balanced. They will meet, usually, from three months to three years. (Actually, we've done a study in one month and we have two groups that have been going on for 50 years — but three months to three years is the usual range.) They will write what I think of as a Ph.D. dissertation to answer the question: it is 200-300 pages long (the last 50 pages are references); the text is fact-based; there is no opinion; it is tightly reasoned; and it is often dry as dust. But it is the definitive answer to whatever the question was. Most of these questions bear on important public policy.

Before the events of September 11, you may have heard discussion about the possibility of new corporate average fuel economy (CAFE) standards. That was provoked by a report we released in August. September 11 has swamped a lot of news coverage, but a report we just released recently was requested by Christy Todd Whitman in the EPA — it was prompted by the President's rescinding of the regulation requiring a reduction in arsenic in drinking water. The administration does not like the report. It says there is no simple model of how many parts per billion is OK, and as far as we can tell, no amount of arsenic is good for you.

We issue one of these reports about every working day, 200 to 250 times a year. All of this discussion is so that you to understand that the Academy is two things. It is an honorific society, and it is a trusted adviser to the nation. We are not part of the government. We are private 501(c)3 corporation, but we operate under a very special set of rules and obligations resulting from the Congressional charter and a number of special laws and executive orders.

Diversity in the Engineering Workforce

OK, now let me get to my main topic. I want to focus on what I consider the *absolute requirement* for diversity in the engineering workforce (I think a lot of what I am about to say applies equally to the scientific workforce, but what I know from a personal perspective is the engineering workforce). I embark on this talk with a bit of trepidation, not because of the message that I am trying to bring to you, but the nature of the reasoning I am going use. This is the sort of thing that might almost be better done with a tightly reasoned paper than a talk, but you're going to get it anyway.

Some people talk about diversity from the perspective of equity, the perspective of fairness. I think that Americans, by and large, are very sensitive to issues of equity, to issues of fairness. But that is not the argument I want to bring forward here.

Other people promote diversity from the perspective of simple numbers. The percentage of the population that is white male is declining. Us guys are going to become a minority fairly early here in the 21st century. In order to have enough scientists and engineers in the workforce, we are going to have to attract a more diverse population. But that is not the argument I am going to give either. I think there is an even deeper reason why it is not just "nice" to have a diverse engineering workforce, but why we absolutely require one!

In order to explain why, I have to share the views I have about the nature of engineering, which, frankly, are not the typical ones. Let me give you the full argument in a nutshell to start out.

First of all, I believe engineering is a profoundly *creative* profession. Point two, the psychological literature says very clearly that creativity is derived from an individual's life experiences. As a result, if we don't have a diverse workforce, we limit the set of life experiences that an engineering team will have and, consequently, we limit the creativity that could be brought to bear.

The stereotype of engineers is not that they are creative folks — it's pocket protectors, white socks and big glasses. But I think that that stereotype is deeply, profoundly wrong. And so to come full circle, I think we lack the diversity that we absolutely need in part at least because of this incorrect perception of the nature of engineering. We have worked ourselves into a destructive negative-feedback cycle, and we need to break that cycle.

When I use the word diversity I certainly mean what you probably thought I meant, namely a collection of folks who mirror the U.S. population. I want to call that “collective diversity.” I also want to talk about “individual diversity,” the breadth of life experiences that a single engineer has.

The Academy has an annual meeting every year and the President is expected to give a talk. I gave a variant of this talk at the annual meeting a couple of years ago. There were a number of reasons why I did it, not the least of which is the Academy is not the most diverse organization you have ever seen. My members do not own the problem of diversity in the engineering workforce. I was trying to get their attention, but there were a number of other reasons why I did it. Let me share just one with you.

Engineering enrollment peaked in 1983. It is down about 20 percent from that now. Graduate enrollment has continued to go up, but that is largely because of the influx of foreign students. The number of American graduate students is declining at about the same rate as the undergraduate population. Now let’s step back. Let’s do a reality check. This decline occurs in the face of the fact that starting salaries are about twice that for people with B.A. degrees.

My economist friends tell me eventually the situation will fix itself. I am not so sure. I think we need to ask ourselves why is it that, even though the salary differences are so great, our profession is not attractive to women and underrepresented minorities? Why is it that, in a society that is so dependent upon the results of engineering, and where salaries are so high, somehow engineering is a repugnant profession?

By the way, as I am sure all of you know, the proportion of the total undergraduate populations that are women or are underrepresented populations is increasing. So it’s worse than the simple numbers suggest — engineering is losing market share. There is something not right here. Whereas minority enrollment in engineering had been slowly increasing, between 1993 and 1999 African American enrollment fell 17 percent. Seventeen percent! For women, enrollment climbed up to just under 20 percent but now seems to be flat. Why is that? What is it that is wrong with what we are doing?

This is not a worldwide phenomenon. I toured Taiwan at the invitation of the Minister of Education a few years ago and 35 percent of the undergraduate population is in engineering. It is 8 percent in this country. In mainland China, 46 percent of the undergraduates are in engineering.

Engineering — A Creative Profession

Let me return to my main argument, and start with creativity. My favorite quick definition of what an engineer does is “design under constraint.” What an engineer does is design — or create — solutions to human problems, but not any solution will do. You have to deal with constraints of cost, size, weight, ergonomic factors, environmental impact, reliability, safety, manufacturability, repair ability, power consumption, heat dissipation, and on and on — there is an incredibly long list of such constraints.

Finding a solution to a human problem that elegantly solves the problem and satisfies the constraints is one of the most creative activities I know of. Notice I used the word "elegant;" let me dwell on that word for a minute. All great engineering achievements — I don't care whether it's Post-It notes or the Golden Gate Bridge — are elegant. They're human, they're spare, they're aesthetic. In Einstein's words they are as simple as possible, but no simpler.

Let me tell you a personal story about myself that bears on this question of creativity and elegance. My father and my uncles were all engineers, so in some sense I was programmed to be one, too. But nevertheless, I can tell you the exact moment when I got *hooked* on engineering. Between my freshman and sophomore years in college I was working for the Teletype company in Chicago. I was a draftsman, inking on vellum. If anything could turn you off engineering, it's inking on vellum! However, the group that I was working with was, among other things, designing an automatic telephone dialer. It was a little gadget that took a punched plastic card and, with little fingers that would "feel" where the holes were, would dial a telephone number. Well, this wasn't the biggest problem that the group had, believe me, but these cards would occasionally bind as they went through the reader.

One day I looked up from my drafting table, looked at that dialer and saw the problem. I knew what was wrong and saw an elegant way to solve it. I mocked up the solution with some cardboard and drafting tape. It worked. We manufactured the parts for about a penny.

It was just a wonderful moment, that moment of creativity, that moment of seeing the *right* solution — the *elegant* solution. I got praise from a bunch of the older engineers. I got a bonus in my paycheck. I still think back on the fact that there were thousands of people who used that darn dialer who never had a card bind. All that was nice, but what *hooked* me on engineering was that creative moment when I saw the *elegant* solution. Looking back over my career, I've had the opportunity on a number of occasions to have those kinds of wonderful moments, and I can remember each one very, very well.

One of the members of my academy, Sam Florman, wrote a book in the middle of the 1970s called *The Existential Pleasures of Engineering*. It is a great book, and he makes the point very well. He talks about the *joy of creation*. It is that joy of creation that I think makes engineering an interesting profession. In the book, Sam cites an earlier psychological profile of engineers: "intelligent, energetic, unassuming people who seek interesting work." Interesting work! Not pocket protector stuff. Interesting work! Creative work!

Teaching at the University of Virginia, a strong liberal arts school, I find more in common with our friends in the fine and performing arts than we do with those in the sciences. Again Sam Florman: "the artist is our cousin, our fellow creator." Another one of my members, Bob Frosch, brought me a quotation from Ladislas Rita, who was the editor of the *Codices of Leonardo DaVinci*. Rita was commenting on the impact that he hoped that the *Codices* would have and said, “At last people will start believing me. DaVinci was an engineer who occasionally painted pictures when he was broke.”

The point is that engineering is *not* poles apart from the creative arts. Quite the contrary, it is of the same cloth. Indeed, almost the definition of what makes one a human, as distinct from one of the other primates, is the use of tools to modify your environment. That is engineering. In many ways I think engineering is among the most humanistic of the disciplines.

Obviously there is also a dull, analytic side of engineering. There is an innate conservatism in engineering that has to do with our responsibilities to the public. It is just like the medical doctors: first do no harm. So, following our most creative moments, we immediately turn around and analyze the bejeebers out of what we have just designed. We try to find all the ways in which it can possibly fail. The more innovative, the more creative the solution you design, the more you suspect it.

I think it is that analytic side, that cautious side, which has become the stereotype of engineering. Instead of celebrating our creations, we try to find their flaws. No one seems to think that painters are dull people, but if you think about how many years Michelangelo spent lying on his back painting the Sistine Chapel, or about the brute strength that it took to put that plaster up on the ceiling from that position, it doesn’t sound so creative.

I have a good friend who is an Emmy award-winning director in Hollywood. A few years ago, he arranged for me to spend a weekend with some Hollywood filmmakers and I was just overwhelmed. They talked the whole time about how dull it was to make films. The amount of time they spend actually shooting a film is miniscule. They then spend months sitting in a darkroom editing the stuff, and apparently it is really dull. Yet that is not the public image.

There is a creative side to engineering. There is a creative side to painting. There is a creative side to filmmaking. There is a creative side to a lot of professions. And there is also a dull side to all those same professions. Somehow only the dull side is in the stereotype of engineering.

OK, so message number one, engineering is creative.

Diversity — Individual and Collective

Now talk about diversity. Let’s begin with a simple assertion: one’s creativity is bounded by one’s life experiences. The psychological literature is almost unanimous in concluding that creativity is not something that just pops out of a vacuum. Creativity is the result of making unexpected connections between things you already know. As a consequence, one’s creativity is bounded by what you know and hence by your life experiences.

I want to emphasize that individual diversity, the breadth of experience that a single individual has, is essential to good engineering. If engineers were really as dull as the stereotype, they'd be lousy engineers. Let me say that again. *If engineers were really as dull as the stereotype, they'd be lousy engineers!* They wouldn't have the breadth of life experiences with which to be creative and hence with which to do good engineering.

Collective diversity, the kind that we usually mean, is just as essential for good engineering. At a very fundamental level, men, women, racial minorities and the handicapped have different life experiences. From the perspective of creative engineering, those differences are the fodder for creative, *elegant* engineered solutions. They are a "gene pool" for creative engineering.

To the extent we limit the gene pool for creativity, we limit the set of creative solutions that we will produce. I believe that my profession is diminished and impoverished when we use a design team that lacks diversity.

It does not take a genius to see that in a world of globalized commerce, our engineering designs must reflect the culture and taboos of an extremely diverse customer base. But it is a lot deeper than that. You can get the marketing department to tell you that women are shorter than men. You can get the marketing department to tell you that there are certain things you do not do in Muslim society. But the important point is that if you limit the set of life experiences on a design team, you limit the set of options that will be considered. The *elegant* solution may not be found.

There is a real economic cost to that. It is unfortunately an opportunity cost. It is a cost measured in might-have-beens, things that did not happen. Opportunity costs are very hard to measure, but they are also very real. Every time we approach a design problem with a pale male team we run the risk of not finding the elegant solution. It is hard to prove that, but I can give you some anecdotal stories.

Until very recently I still had two graduate students. I am now totally a policy wonk, a total creature of Washington — but until last spring I had two graduate students, both of whom happened to be women. One of them also happened to be Chinese. We were working on computer security and she came to me with a potential dissertation topic. I told her it was an impossible problem — it couldn't be solved.

The problem was to run a program on a hostile computer and guarantee that the program either had not been tampered with or we would know that it had been tampered with. By a hostile computer I mean a computer owned by "the bad guys." The bad guys had complete control of the computer, they could pull a plug out of the wall, they knew what all the code was, they had all the passwords, they had anything that they might need in order to compromise the program she was trying to run. Moreover, this program had to run virtually indefinitely. So the bad guys had as much time as they wanted to do whatever they were going to do.

As I said, I told her that's impossible. Darn it, she found an *elegant* solution. I don't mean just a solution, but a truly elegant solution. I don't honestly know whether it is because she is a woman or because she is Chinese, but her set of life experiences let her see a solution that I would never, ever have found. My Western, male, linear, left-brain would never have seen the solution. By the way, after she told me what the solution was, and I marveled at it for a while because it was so elegant, I was the one who was able to generate the proof that it worked — the nice linear, male, left-brain proof.

Conclusion

So let me pull the threads of creativity and diversity together. I believe that not the only but a central problem with declining enrollment in engineering, especially among women and underrepresented minorities, is our image. I can't see any other explanation for why it is that such an interesting profession, which has had such an enormous impact on the quality of our lives, and which compensates its practitioners so extremely well, is not attractive. In fact the image is actually repulsive.

It is not a correct image, but it is the one that the public seems to have, at least in this country and most of the rest of the West. It is not the image in China, believe me. More than half of the ministerial posts in the Chinese government are occupied by engineers.

In this country, the image of engineers was in fact positive from the 19th to mid-20th centuries. During this period there were films, plays and novels in which engineers are the heroes. Walt Whitman: "singing the great achievement of today. Singing the strong light works of engineers." Robert Lewis Stevenson writing about the engineering of the transcontinental railroad: "If it be romance, if it be contrast, if it be heroism we require, what was Troy to this?"

It is not ordained that engineers must have the image of narrow, dull nerds! It is not ordained that the contributions of engineers to society be discounted. It is not ordained that we have an image that is repulsive to the diversity that we require in order to engineer well.

Let me sum up. Diversity is essential to good engineering. We have to face the fact that for some reason or other, the diverse population finds engineering repulsive, repugnant. That they do is evident in the enrollment numbers. There are many reasons for that, and I have touched on only one. You have been talking about lots of others. The lack of mentors. The lack of role models. Poor counseling. The nature of K-12 education, where teachers tend to turn students off — particularly women and minorities — of science and mathematics.

But among the list of things I think we need to get on the table is this incorrect caricature of what one's life as an engineer is like, and what engineers contribute to our society. The stereotype does not have to be that way. It has not been that way in the past in the United States, and it is not that way in other places in the world.

There is no silver bullet that is going to fix this problem. It takes a change in attitude. That is not an easy thing to affect. But symposia like this are one of the ways that that is going to happen. And so, I cannot applaud enough what Bryn Mawr is doing. This is a problem that we must solve.

Setting the Agendas: Education and the Workplace

Following the opening panel discussion, those attending the symposium participated in workshop sessions to examine specific policy and practice issues affecting women that have emerged from recent changes in scientific investigation, education and workplaces. Each workshop group developed specific proposals to advance opportunities for women, and identified corresponding strategies for action in their home institutions.

Dr. Maxine Savitz, Member of the National Science Board and the National Academy of Engineering, and Dr. Maria Pellegrini, Program Director at the W.M. Keck Foundation, provided leadership for these sessions. In large group meetings that preceded the first workshop sessions, Drs. Savitz and Pellegrini reflected on key points raised by the opening panel and led discussion of issues relevant to all workshop groups. Following the final workshop sessions, participants reconvened for lively discussion of the recommendations made by the various workshop groups to create new opportunities for girls and women in science, technology, engineering and mathematics (STEM) education and professions.

Education Workshop I: New Learning Technologies

FOCUS

How can schools and colleges use new learning technologies to advance science interest and education among girls and young women?

MODERATORS

Lisa Bievenue, *Education Research Associate, National Center for Supercomputing Applications, University of Illinois/Champaign-Urbana*

Paul Grobstein, *Eleanor A. Bliss Professor of Biology and Director of the Center for Science in Society, Bryn Mawr College*

PARTICIPANTS

Participants included people actively involved in the creation and dissemination of new learning technologies, people using such technologies in college and pre-college teaching, educators interested in using such technology, and parents concerned about finding ways to enhance science education for their children.

DISCUSSION SUMMARY

The ongoing development of new learning technologies was generally seen as a promising avenue for advancing science interest and education among girls and young women. While early, probably necessary, evolutionary phases of this development largely replicated traditional pedagogical styles, there is an increasing movement toward materials that engage students in individualized ways in interactive learning experiences, which stress learning by doing and make available a remarkably rich array of materials, experiences and techniques. These seem likely to contribute to a broad rethinking of the presentation of science in a way that will better engage and maintain interest in science among young women at all educational levels.

For science educators, new learning technologies make it possible to:

- Teach science and scientific perspective not as an isolated subject but as beginning with and related to questions of general interest to students;
- Engage students in doing meaningful explorations themselves;
- Provide students with usable forms of sophisticated visualization and simulation tools actually used in science;
- Make a wide variety of materials available to students, from which they (or their teachers) can “individualize” their education, and find approaches and topics that fit their own interests, backgrounds and learning styles;

- Give students and teachers the encouragement and capability to make contribu--tions to the scientific observational base and the interpretation/discussion of that data.

Sample Uses of New Learning Technologies in Science Education

- Pieces of Science (http://www.sln.org/pieces) — classroom activities created by teachers, available online.
- Science as Exploration Institute (http://serendip.brynmawr.edu/local/suminst/eei01/shcedule.html) — classroom activities created by teachers, available online
- StarLogo (http://el.www.media.mit.edu/groups/el/projects/starlogo/) — downloadable interactive software.
- Making Sense of Complex Phenomena Through Building Object-Based Parallel Models (StarLogoT) (http://ccl.sesp.northwestern.edu/cm/index.html) — downloadable interactive software.
- GirlTECH (http://www.crpc.rice.edu/CRPC/Women/GirlTECH/) — lesson plans and training materials available on line to increase girls' interest in computer science.
- Eisenhower National Clearinghouse (http://www.enc.org/) — includes information on integrating technology and teaching, as well as an array of online curricular materials for K-12 math and science teaching.

While there is substantial promise and activity in the development of new learning technologies, at the moment this work is largely occurring in isolated ways.

> ***Recommendation:*** *It would be advantageous both to the creators of such materials and to those interested in making use of them to have a central and continually updated directory of information about ongoing developments. Such a directory, which could be maintained by an organization such as the NSF's Division of Education and Human Resources, could serve to provide critical analyses of existing materials as well as of the general direction of ongoing development.*

The workshop also engaged the question of "learning styles" and possible population differences between females and males in the kinds of experiences they find engaging. Participants discussed the following learning style continuums:

- More inclined to (a) "mess about" vs. more inclined to (b) plan in advance/pursue directed goals;
- More inclined to (a) accept goals inherent in a task vs. (b) want to create a product on one's own;
- More inclined to (a) "test" understanding against constraints vs. more inclined to (b) "free play;"

- More inclined to (a) focus on individual activities in relation to an external task vs. more inclined to (b) focus on interpersonal dynamics.

Most existing science education materials that use new technologies emphasize (a)-type activities, though there are clear examples of (b)-type materials, such as graphics packages and the Sims-type of computer games.

> ***Recommendation:*** *If existing materials are more appealing to males than females (on a population basis), this difference must be better understood and changes must be made in educational technologies.*

More important, perhaps, is the opportunity to use technology to create science education materials that appeal to a variety of learning styles.

> ***Recommendation:*** *By combining (a)- and (b)-type activities in a more balanced way, we can realize the potential of new learning technologies to help engage girls and young women in science and technology*.

Education Workshop II: Effective Teaching

FOCUS

What pedagogical strategies work to bring girls and young women into areas in which they remain underrepresented and become increasingly underrepresented through the education and workplace pipeline — computer science, engineering, physical sciences and mathematics?

MODERATORS

Suzanne E. Franks, *Director, Women in Engineering and Science Program, Kansas State University*

Kim Ann Zajack, *Director of Pre-College Programs, The Douglass Project for Rutgers Women in Math, Science and Engineering, Rutgers University*

PARTICIPANTS

All participants were science educators. Although most were K-12 teachers, the group also included science museum education staff, directors of programs for girls and young women in science, and university/college faculty and staff.

DISCUSSION SUMMARY

Participants identified six key issues affecting girls' interest and persistence in science, math and technology.

- Many girls still do not understand they need a career;
- Many careers in science, engineering, technology, and related fields have a negative — or nonexistent — public image, especially among girls;
- We still do not attract enough capable college students into the professions of mathematics and science teaching;
- Teachers in these areas require different teacher training that emphasizes inquiry-based approaches and prepares them for real-life classrooms;
- Teachers in many schools lack adequate materials and resources for inquiry-based science and mathematics education;
- Teachers need summer programs in which they actually do science or can learn new pedagogical techniques — and funding to enable them to participate in these programs.

A wide-ranging discussion led to a series of recommendations to engage girls, and to support and improve science teaching for girls and for all children.

Engaging Girls

1. We will be most successful if we get girls excited about science early. This effort has to extend beyond PBS and public-access broadcasting in order to have a significant effect, and should use formats to which kids respond, such as the "fun" strategies of teaching employed by Sesame Street. Kids crave repetition, and video formats allow us to have a huge impact on their interests if used imaginatively.

2. Kids — and teachers — need to learn that science is less about answers than about asking good questions and figuring out ways to answer those questions. This is an especially important lesson for girls, many of whom find it difficult to keep asking questions until they obtain the answer they need. *Science and math teacher education programs need to make this approach part of their own pedagogy as well as part of their curriculum.*

3. K-12 curriculum design should draw on the expertise of a wide range of professionals — child development experts, scientists/mathematicians, education faculty and even theater professionals — to create classes that are exciting, age-appropriate and challenging.

4. All kids need to hear from teachers that it is OK for science and math to be hard: "It's hard, but it's also fun."

5. Inquiry-based learning should be the model for science education from the earliest grades. Teacher-education programs should use and teach this pedagogy, and standards-based curricula should be designed that can measure such learning.

6. At all educational levels, all children profit from bringing practicing scientists, engineers and high-technology professionals into the classroom to talk about their work. Such visits are most effective if they are part of a regular program of visits rather than isolated events.

7. Participants in this workshop concurred with national reports that identify middle school as a point when many girls turn away from math, science and technology. To counter that trend they called for:

   - Outreach to counter social pressures driving girls from sciences, such as women scientist mentors & classroom speakers;

   - More "smart camps" and in-school science enrichment for middle-school girls (most are targeted at high-school-age students, when many girls have already dropped out);

- Integration of math and science across the curriculum;
- More opportunities to do experiments, especially on topics girls care about.

8. Schools need to do a better job of teaching girls that they will need a career and the capacity to support themselves and possibly a family. This requires teaching girls basic economics, as well as creating a sense of opportunity and excitement about a wider array of career paths.

   Children, parents and guidance counselors are not aware of the wide array of career paths in science and technology fields. Schools need to institute professional development programs for counselors and information programs for parents and children from middle school onward.

9. Even where they exist, science and technology mentoring programs do not have a reliable positive impact on the girls they serve. Participants called for more effective dissemination of successful models and for new strategies to increase the interest of older women in becoming mentors.

Enriching Teachers and Teaching

1. Teacher education programs must teach and model inquiry-based learning that teaches students to ask good questions and search for good answers.

2. New teachers need time to learn to teach, and experienced staff need to be renewed in their teaching. Mentoring and ongoing professional-development opportunities to learn new content and pedagogy in math and science are crucial to success and persistence in the profession.

3. Many teachers need more good curricular materials. Science museums can play an important role in developing and disseminating programs to public libraries as well as schools.

4. Schools should support more team-teaching in science. Different members of a team can appeal to their students varied learning styles by teaching the same concept in different ways. Teams can more easily divide classes into smaller sections to facilitate cooperative group learning.

5. Summer enhancement programs for math and science teachers pose opportunities and challenges.

   - Many teachers struggle to obtain funding to attend enrichment programs or create enrichment programs for students. Foundations and corporations can do more to support effective enrichment programs, and university partners can assist K-12 teachers with workshops on grant-writing.

- Teachers respond positively to programs in which they do experiments that they can then include in their own classes. Familiarity helps create the confidence to introduce new materials and approaches into their own courses and creates the experience to offer effective guidance to their own students.

- Science and engineering companies should create more opportunities for teachers to work in laboratories during the summer. Many teachers have no personal experience in research, testing or production. Participants felt these corporate internships would complement university-based workshops.

6. Participants recommended development of a national database or clearinghouse of professional-development workshops and summer opportunities.

7. Schools need to schedule time for teachers to engage in unstructured professional exchange; teachers in turn must make a commitment to take part in these discussions.

8. Colleges and universities generally look at K-12/university partnerships as a one-way relationship. Teachers' expertise in teaching can benefit their university partners.

Education Workshop III: Preparing Women STEM Majors to Succeed

FOCUS

How can colleges and universities prepare women to succeed in math and science as undergraduates? In graduate school? In an expanding science and technology workplace?

MODERATORS

Natalie Feilchenfeld, *Technical Team Leader, Silicon Germanium Technology Development, IBM Microelectronics*

Toby M. Horn, *Consultant, District of Columbia Public Schools – DC ACTS. Former Coordinator for Biotechnology Outreach, Fralin Biotechnology Center, Virginia Tech*

Rebecca Mercuri, *Assistant Professor of Computer Science, Bryn Mawr College*

DISCUSSION SUMMARY

Issues explored in this workshop fall into three broad categories — what young women must learn to persist in STEM, how they can best learn (in terms of pedagogy and institutional settings), and how institutions can help sustain women's interests and ambitions in STEM fields.

Although this workshop specifically concerned the persistence of young women in STEM fields as undergraduates and in postgraduate work/study, many of the recommendations were made for implementation in K-12 education as well. In framing issues of girls' persistence in math and science as a continuum, the recommendations offered here illustrate opportunities to share successes across what is often experienced as a great divide between undergraduate and K-12 instruction. Many strategies to engage girls in math and science and support those interests are effective across a relatively wide age spectrum (e.g. mentoring, cooperative learning), as long as they are adapted to the needs and interests of those served.

In making the following recommendations, participants also recognized that some STEM fields are moving targets, and that teaching, mentoring and career information must continually evolve to keep up with new opportunities.

1. As a number of studies have documented, young women (as a population) enjoy learning science, math, engineering and technology when they have opportunities to learn through:

   a. Cooperative groups;

   b. Solving problems to help society;

   c. Communication with others.

In order to increase the number and persistence of young women in STEM fields, departments and faculty should respond to these preferences in systematic curriculum revision.

2. Math is key to success in STEM careers. Persisting in K-12 math leaves the option of a STEM major open to young women; continuing with math, even if not a STEM major, creates opportunities for college graduates to move into STEM organizations.

   NSF-sponsored Project Kaleidoscope programs have helped change and continue to change how math is taught at the college level to provide more context-based and cooperative learning. As noted above, several studies have demonstrated that such pedagogy makes math more appealing to many females and many members of underrepresented groups. Advocates of improving the persistence of girls/young women in STEM should work to increase number of college-level math programs using this approach and to help adapt and disseminate this pedagogy to K-12 math teachers.

3. Liberal arts colleges and women's colleges have the best potential to produce more majors in these fields because they do not have "gatekeeper" classes designed to exclude the majority of introductory students from a majors pathway.

4. Women are lagging further behind in computer science. STEM courses should provide opportunities to make connections to applications of computer science.

5. Faculty must have the same high expectations for young women in STEM fields as they have for men.

6. The Internet can play an important role in increasing girls' and young women's access to different approaches to science and technology mentoring and career information. Participants noted in particular the potential of MentorNet as a source and model of online mentoring.

7. Participants advocated development of a Web site, perhaps hosted by Bryn Mawr, that would connect young women to a database of information about women who have careers in STEM and provide links to other Web sites profiling other successful women in STEM fields (e.g. SACNAS).

   Participants recommended that the database use a structured interview format, including questions that would be of particular interest to younger women (e.g. what is your day like? What were your interests in high school and college? Who influenced you?) as well as those focused upon more traditional career information (How did you become interested in your field? What do you like about it? What if any barriers did you have to overcome? What has contributed most to your success?)

Education Workshop IV: Supporting Women STEM Faculty

FOCUS

How can colleges and universities more effectively encourage and support women faculty? How can women faculty most effectively work to achieve institutional changes that would promote professional success and satisfaction?

MODERATORS

Amy Bug, *Associate Professor of Physics, Swarthmore College*

Janice Hicks, *Program Director, Analytical and Surface Chemistry, National Science Foundation*

PARTICIPANTS

All participants were college and university faculty, representing seven STEM departments and every point on the academic career path (new assistant professor to college president). Several had senior administrative responsibility in the present or recent past (department chair, associate dean of faculty, vice chancellor for research, president, NSF division head), and thus brought multiple perspectives and concerns to the discussion.

DISCUSSION SUMMARY

In preparation for the workshop, participants read several significant articles on women scientists and academic careers. The workshop began by asking participants to imagine a future when gender equity is no longer a problem in college and university STEM departments. The ensuing discussion focused on six characteristics of such a future.

1. Institutions and departments strive for and achieve parity in hiring, promotion and tenure. At minimum, parity means a percentage of women on STEM faculties at all ranks equal to that of women earning Ph.D.s, M.D.s, etc. There was not agreement on what parity would mean.

2. The atmosphere of departments and institutions is changed: women would not feel like they and their actions are under the microscope, and their comments are heard rather than ignored.

3. The tenure system has more flexibility:

    a. Varied models for a faculty member's professional "life span" (e.g. eras of research, eras of teaching).

    b. Varied hiring agreements (option of fixed-term contracts rather than tenure or nothing).

   c. Tenure system that rewards achievements and contributions in more individualized way.

4. There are possibilities for science and engineering faculty to re-enter the academic workforce, should a leave for personal reasons be necessary.

5. Institutions and professional organizations demonstrate respect (in terms of monetary reward, professional recognition, etc.) for individual career path choices.

6. Students and academic professionals alike have information available to them about different career paths within the academy. All would receive training in "survival skills" as graduate students/postdoctoral fellows (e.g. negotiation skills for salary and start-up facilities) and as new faculty (e.g. managing a research group, setting priorities amid multiple demands).

This opening session led participants to focus subsequent discussion on tenure and institutional/ professional climate, which they identified as core issues in achieving gender equity for women STEM faculty.

Tenure

Participants began with a discussion of obstacles women face in achieving tenure, and possible alternatives to the current structure of academic hiring and measures of professional achievement that lead to tenure.

1. Tenure-track is a relatively short period of time — and for many women faculty, it coincides with childbearing years. This presents a formidable barrier for many women, who may reject the academic career path on these grounds alone.

2. What is tenure about? It is about academic freedom, but many argued that it is not absolutely essential. The "up-or-out" moment is extremely brutal.

3. Participants explored alternatives that would enable women to pursue academic careers in a variety of ways.

   a. Give the faculty member the choice to come up for tenure or work on renewable contract.

   b. Establish a shorter tenure clock that sets different criteria for evaluation (minimal sufficiency at present, significant weighting of long-term promise).

   c. Establish the option of a 10-year clock. Faculty would begin positions, then choose either the current six-year clock to tenure or 10-year terminal appointment.

4. Many faculty are asked to do too much. Overload (research proposals, papers, course loads, even startup companies) in a very competitive atmosphere can ultimately be detrimental to many good scientists — male and female.

5. Two professional tracks already exist in a number of universities: a research track and a teaching track. This division is often gendered.

   At many such institutions, faculty can in theory move between these tracks at different phases of their career. In practice, however, once one has chosen one of these tracks, one is "slotted."

Participants also recommended concrete action plans for individual institutions to improve tenure success among women STEM faculty within the current system of academic hiring and promotion.

1. Junior faculty should be provided with the means to gather information about tenure from inside and outside their institution:

   a. Internally, institutions should set up a mentoring program to pair senior and junior women. Department chairs and the dean should meet with them on a regular basis.

   b. Externally, professional organizations should offer tenure workshops by discipline and across the disciplines (through the auspices of an organization such as the American Association for the Advancement of Science).

2. Mentoring must be institutionalized. All junior faculty should be mentored. Mentors should be chosen selectively by deans, provosts or presidents. Individual institutions should recognize mentoring (e.g. Penn State presents an award to the best mentor among senior faculty).

3. An individual institution might sponsor an annual mentoring program for faculty to provide mentoring, train mentors and recognize notable mentors. Mentoring is needed at all levels — mentoring "down," mentoring "up" and mentoring "horizontally."

   EDGE (Enhancing Diversity in Graduate Education), a program developed by Bryn Mawr and Spelman Colleges to enhance the success of new women graduate students in math, is a notable example of discipline-specific mentoring (see http://www.brynmawr.edu/Acads/Math/edge/edgesum.html). Mentoring through graduate school and through the tenure period will be added to the program with the aid of recent grants from NSF and The Andrew W. Mellon Foundation.

4. Senior faculty must protect junior faculty from too much service.

5. Institutions should explore the possibility of flexible trajectories toward tenure. Note: significant differences of opinion on this issue existed among participants.

Climate

Participants recommended the following concrete steps that can be taken now to improve institutional and professional climates for women.

1. Gender equity can not remain an issue of the minority. Women must involve men in the planning stages of all projects, and should encourage men to be active participants in events and initiatives focused on gender and institutional climate.

   More broadly, women concerned about gender equity need to formulate ways to talk to all skeptics about gender equity issues — women and men — so as to have a demonstrable effect on climate.

2. Institutionally, climate issues might be addressed by a faculty task force, one with equal numbers of men and women.

3. Advocates of gender equity should identify those within the institution and the STEM departments/colleges whose voices carry weight and work to engage these individuals in dialogue. Those responsive to climate concerns should be drawn into planning and implementation of policy.

4. Provosts and deans should institute rewards and awards for improving climate (e.g. hiring and retaining more women and underrepresented minority group members in STEM departments).

5. Institutions must provide opportunities for women STEM faculty to develop leadership skills and serve in leadership positions. Women faculty should enlist the active support of existing women academic leaders to support efforts to improve climate.

6. Mentor and peer networks among women STEM faculty should actively support individual women in protests/appeals related to gender equity.

Workplace Workshop I: Women and Networking

FOCUS

How can women create and use professional science and technology networks more effectively?

MODERATORS

Julie Sheridan Eng, *Director, New Product Development, Agere Technologies*

Susan Fitzpatrick, *Senior Scientist, Women's Health Research Institute, Wyeth Research*

INTRODUCTION

The workshop began with an ice-breaker that was also an unannounced exercise. Participants walked around the room and introduced themselves to others for about three minutes. Each participant was asked to relate what she remembered about each person. The exercise made three points.

- Those introducing themselves learned what people in the room heard from them as they introduced themselves in a "cocktail party" environment.
- Each person discovered how well she listened to people introducing themselves compared to others in the room who also met the same person.
- All then could also draw the conclusion that it is helpful to have an "elevator speech" — a few lines that you can recite about yourself, your job, your goals, what's important to you — if you run into someone you want to meet and have a limited time to share this information.

WHAT IS NETWORKING?

The workshop arrived at a consensus definition of *networking*: "improving communication with other people."

People viewed networking as expanding their contact base. People use networking to find opportunities, to get information or a job, to meet other people. It also provides new experiences. Several people looking for jobs said that they would like to learn how to meet and interact with high-power people who may be helpful in their careers; they viewed selling themselves as an important part of networking. Others further on in their careers saw networking as both give and take, in which they were offering information and help as much or more than receiving it. Having a network of experts you can consult on your job can help increase your job efficiency. Networking also offers an opportunity to feel a sense of connection and engagement with others that may have a common interest with you. And, it can be general, such as meeting other women in science, or specific, such as trying to meet a particular person who can help you out in your job.

NETWORKING ISSUES

Issues included: how, when and where to network? How to introduce yourself, what is the protocol? How can we improve our networks? What is an informational interview and how to conduct one? And how do we maintain our networks?

How, when and where is anywhere, as long as you do not waste or monopolize the other person's time. If you have a particular request in mind, make it clear and do it early in the conversation. For example, "I'd like to stop by your office for 15 minutes next week to get your advice on a decision I'm making." If you had met a person before, but weren't sure they remembered you, to feel free to say something like, "Hi, I'm Jane Brown from AT&T, we met briefly in the Networking Workshop at the Bryn Mawr College Women in Science Symposium last year."

Maintaining your network was a topic of some discussion. Some people suggested sending e-mail messages every once in a while and/or sending information you come across that you think that person might be interested in. Several reminded the group, however, that a fine line exists between networking and stalking.

NETWORKING BARRIERS

Women often don't network effectively out of insecurity regarding networking.

NETWORKING ACTION ITEMS — INDIVIDUAL

1. Identify a goal for each networking opportunity. Do you want to meet three new people? Is there a particular person you would like to meet, or someone from a particular company or industry? If so, thinking about this in advance will help to guide you to interact with people in a way that helps you meet this goal.

2. Be more specific in conversation. "I'd like to speak to you sometime, I think I could learn a lot from you" is not as effective as "I'd like to stop by your office next week for 15 minutes to get your input on a project I'm working on [add a detail or two here]." The more the person you are seeking information from understands the time commitment and goal of your interacting with them, the more likely you are to get their time.

3. Develop an exit line. Such a line provides a tactful way to get yourself out of an unproductive situation that isn't helping you reach goals defined in (1) above.

4. Join a professional society: a lot of networking goes on at professional society meetings and committees. For example, many members of the Philadelphia Association of Women in Science (AWIS) chapter attending the Bryn Mawr symposium already knew one another and keep up through AWIS activities.

5. Get involved in planning events and participating on committees. This is a natural way to meet new people and interact with them informally.

NETWORKING ACTION ITEMS — COLLEGES SUPPORTING WOMEN IN STEM FIELDS

1. Sponsor networking events for alumnae. Include undergraduates.
2. Encourage more undergraduate involvement in events like the Bryn Mawr College Women in Science Symposium, which provided a great potential networking environment for students.
3. Sponsor a Women in Science Symposium annually, perhaps with rotating themes, such as leadership, entrepreneurship or career development.
4. Offer a networking class (evening, part-day) for undergraduates and graduate students.
5. Invite alumnae to give career talks, which also help build networks for students.

NETWORKING ACTION ITEMS — OTHER

Bryn Mawr and other colleges should work with a national organization such as AWIS to develop a Web-based listserve where information can be shared and questions and answers can be posted. It could begin modestly, like the computer Systers network, and expand as support and interest exists.

Workplace Workshop II: Women in New Economy Enterprises

FOCUS

What strategies can enable more women to break through largely unacknowledged barriers in New Economy careers and entrepreneurship?

MODERATORS

Lori Perine, *CEO, Interpretech LLC. Former Deputy to the Associate Director, Technology, White House Office of Science and Technology Policy*

J. Pari Sabety, *Director, Technology Policy Group, Ohio Supercomputing Center*

DISCUSSION SUMMARY

Women entrepreneurs in New Economy enterprises face many of the same barriers as their counterparts in Old Economy businesses. The most significant differences for New Economy entrepreneurs may be the even smaller number of women in technology than in other business fields and the assumption that women are averse to the high risk culture of new economy entrepreneurship.

Participants — women working in traditional and New Economy technology companies and economic development, and graduate students considering various career tracks — focused their attention on three areas affecting women in New Economy enterprises: the sociology of business, access to capital and institutional change. Throughout these discussions, participants sought to identify unacknowledged as well as acknowledged barriers. The group looked for ways in which issues facing women in new economy enterprises and successful strategies of response might be applicable to other underrepresented groups. Participants also explored the sometimes competing agendas for "surviving and thriving" individually and changing the institution for a broader population.

THE SOCIOLOGY OF BUSINESS

Issues and Barriers

- Knowing the rules of the game;
  - gauging which battles to fight
  - understanding the language and culture of business
  - knowing how to leverage existing networks for professional purposes
- Women's socialization regarding risk and failure;
- Adequate social/family support systems;

- Age and generation differences;
- Diversity of values: women encounter value sets different from their own about what constitutes success, what is achievable.

Recommended Strategies

- Seek out research on sociological aspects of business;
- Be aware of and leverage changes in cultural and economic forces;
  - the New Economy emphasis on distributed/virtual business creates new opportunities for women;
  - "Rules of the Game" — soccer metaphors (watch the pattern, watch where you are in relation to other players, pass to be effective) are replacing the previously dominant football metaphors (command and control strategies, the quarterback as hero/leader). Women can capitalize on this cultural shift.
- Encourage women to explore the full range of STEM career opportunities.

ACCESS TO CAPITAL

Issues and Barriers

- Isolation (sheer lack of numbers);
- Access to capital;
  - Unknown to money networks
  - Business experience (especially in developing new ideas to profitability)
  - Track record (in profit and loss positions)
  - Credibility.
- Risk;
  - Venture capitalists, other investors perceive higher risk with women entrepreneurs
  - Women tend to be more risk-averse to failure.

Recommended Strategies

- Find an entrepreneurship mentor;
- Actively network with successful men and women;
- Seek out women business owners from all sectors with capital to invest;
- Put men on the business team (especially in the CFO position);

- Network, network, network for and among potential investors in absence of old-boy network;
- Track data to create an accurate risk-profile of women-directed ventures, especially in your own industry.

INDIVIDUAL SUCCESS AND SYSTEMIC CHANGE

Issues and Barriers

- Double-standard for women's behavior in the workplace;
  - Finding the line between assertive and "aggressive"
  - Conflicting advice from mentors and managers about adapting vs. being yourself/innovative
  - Conflicting advice from managers on what it takes to be successful.
- Situations which require a choice between personal advancement and achieving institutional change.

Recommended Strategies

- Assess/balance short-term vs. long-term career needs;
- Self-assessment of comfort with being an agent of change.

THE ROLE OF COLLEGES AND UNIVERSITIES

Participants in the workshop agreed that work to bring more women into New Economy enterprise and entrepreneurship should begin during college. They recommended the following initiatives to encourage and prepare women — and indeed all students — to enter an economy transformed by new technology.

- Train all students to be STEM-literate;
- Offer more interdisciplinary work and courses in STEM fields;
- Give credit for business and research internships;
- Develop career planning activities focused on new economy industries and entrepreneurship;
  - Help students understand how liberal arts majors translate into entrepreneurial skills
  - Provide information about what lies beyond the campus, especially the options for STEM majors in varied research settings and outside labs
  - Offer information and resources to help students acquire relevant external experiences

  - Encourage student participation in professional associations

- Promote alumnae accomplishments in entrepreneurship and business ownership. Document the history and career development of alumnae in STEM;
- Create forums to bring alumnae experience back to undergraduates and faculty.

Workplace Workshop III:
Risk-Taking and Leadership

FOCUS

Risk-taking and leadership: what can women from academic, corporate and government science learn from each other?

MODERATORS

Jong-On Hahm, *Director, Committee on Women in Science and Engineering, National Research Council*

Elizabeth F. McCormack, *Associate Professor of Physics, Bryn Mawr College*

PARTICIPANTS

The 20 participants in this leadership workshop ranged from graduate students to distinguished research scientists and CEOs, and were nearly evenly divided between those working in corporate research or management and those in academic or government research. Participants noted the value of cross-sector and cross-generational discussions of risk-taking and leadership issues as a complement to traditional peer group sessions.

DISCUSSION SUMMARY

Participants began by identifying the characteristics of an effective leader so as to assess potential barriers to leadership and risk-taking for women. A good leader:

- Has expertise, experience, visibility and perspective;
- Asks questions, listens well, sees connections and is confident in judgement;
- Supports realistic assessments, does scenario and contingency planning;
- Leverages efforts;
- Is open-minded, acts fairly and practices respect;
- Exhibits passion and optimism, motivates others;
- Recruits talented people;
- Is connected to people, has good social skills, communicates well and participates in networking.

Many women face similar difficulties in assuming leadership and succeeding in leadership roles. These challenges fall into the categories of:

- ***Workplace Style:*** a value for consensus, a need for information to deliberate decisions, a desire for roadmaps and a reluctance to take on the more unrewarding tasks;
- ***Social Style:*** empathy for all, fear of not being liked ("terminal niceness");
- ***Confidence:*** the "impostor syndrome," fear of failure;
- ***Workplace Realities:*** reluctance to engage in self-promotion, expectation that hard work is automatically rewarded.

Of course, some barriers to leadership and risk-taking continue to be posed by the institutions in which women work (e.g. aggressive behavior is not often rewarded in the case of women) and live (many women still bear greater responsibility for family and community obligations). While these are significant impediments, participants focused here on identifying individual incentives and strategies for successful risk-taking and leadership development.

- ***Change Perception of Risk:*** recognize risk as the flip side of opportunity; see risks as opportunities to learn something new; identify risks and ask, "What is the worst that can happen?"
- ***Preparing for Risk:*** find a mentor to explore risk scenarios; minimize impact of risks taken; do contingency planning;
- ***Create Allies:*** participate in a network of support; practice peer mentoring; use a "buddy system" in which each promotes the other;
- ***Changing Attitudes:*** "Just Do It" — it is easier to gain forgiveness than permission.

Participants then prepared to "just do it" rather than file their notes away. Each identified and committed to taking a workplace risk, and agreed to follow up with one another during the following week.

Recruiting and Retaining Women in STEM Fields

Representative Connie Morella (R-Md.)

INTRODUCTION

NANCY J. VICKERS, President, Bryn Mawr College

We welcome with great pleasure Congresswoman Connie Morella, who joins us today to provide a national policy perspective on issues of gender equity in science, education, and the science and technology workforce. An eight-term representative of Maryland's 8th District, Congresswoman Morella has focused her legislative efforts on scientific research and development, education, equity for women, the environment and the federal workforce.

Connie Morella is a long-term member of the House Science Committee, where she has made technology transfer a priority and has worked to create collaborative partnerships between federal laboratories, industry and universities. She has been a leader in forming national recommendations to address the underrepresentation of women, minorities and persons with disabilities in the science and technology workforce. This latter work includes sponsorship of the legislation that established the Congressional Commission on the Advancement of Women and Minorities in Science, Education and Technology (CAWMSET). Congresswoman Morella is a former co-chair of the Congressional Caucus on Women's Issues and is recognized nationally for her work on children's issues, domestic violence and women's health, educational, and economic-equity issues. She has provided leadership on natural resources and sustainable development for which she has earned recognition from many environmental groups. Presently, she is also chair of the Government Reform Subcommittee on the District of Columbia and continues her long service on the Civil Service Subcommittee. On the international stage she has represented the United States at the U. N. Conference on Population and Development in Cairo, and co-chaired the congressional delegation to the U. N. Fourth World Conference on Women in Beijing.

It is a pleasure and privilege to welcome Congresswoman Connie Morella to Bryn Mawr and this symposium.

CLOSING ADDRESS

CONNIE MORELLA

I commend you on the program that you had yesterday and what continued today. I know that you have heard from wonderful panelists, many whose lives have also intersected with mine in the fields of science, engineering, and technology in terms of promoting women. Catherine Didion, for example, has worked side by side with me in her role as executive director of the Association of Women in Science. Dr. Jane Butler Kahle from NSF; Dr. Maria Maccecchini, adding a private sector perspective as CEO of Annovis, Inc; Dr. Anne Thompson, NASA, again bringing in the public sector; Dr.

Priscilla Grew, a professor at the University of Nebraska, bringing in the academy: the make-up of your opening panel says to me what this is all about, and that is partnerships. For us to succeed in this endeavor and in so many others, it is necessary to have a partnership of the public sector, the private sector, and academia. And you have certainly done all of that here.

The terrorist attacks of September 11 that horrified all of us, swept away our innocence and replaced it with grief, anxiety and anger, also left us with a firm resolve that we would stand together as a nation, and work with other nations who like us promote respect and are willing to defend the liberty and the opportunities that we have. So it has in a way brought us all together in a resolute determination that we will make sure that the perpetrators are punished so that we can enjoy the freedoms that we have taken for granted up to this point.

But I see this also as the point of the need for science and technology. Coming from Washington, D.C., where there's been such a problem with our office buildings, the postal facilities and the Supreme Court, people are clamoring for answers to what is happening with regard to anthrax. What about smallpox? What about computer security? There are so many facets of science where the needs are there, and I can see as we move out of this symposium that a lot of the answers are going to come from the women in this room and also those whom you touch outside of this room.

I'm also very proud of the fact that you have had this conference here at Bryn Mawr. I thought I knew something about Bryn Mawr and its earliest background. But Bryn Mawr in 1885 actually was the very first women's college to offer graduate education all the way through to the Ph.D. to women. This was at the same moment in history that Myra Bradwell was not allowed to practice law even though she had studied it. Bradwell vs. State went all the way to the Supreme Court, where Bradwell lost her appeal. Writing for the majority, Justice Bradley said, "The natural and proper timidity of women unfits them for certain professions of civil life. The natural destiny of women is as wife and mother. This is the law of the Creator." Sandra Day O'Connor recalled Justice Bradley's remarks when she became the first woman on the Supreme Court. Wherever he is now, I'm sure he knows he was absolutely wrong. But then, those who founded Bryn Mawr knew that at the time. You were there, taking care of women's education even beyond the undergraduate. And I commend you for that.

Bryn Mawr is in particular a perfect place for demonstrating the success we can achieve in math and science education for women. Bryn Mawr was one of the eight institutions in 1998 to receive a National Science Foundation Presidential Award for Excellence in Science, Math and Engineering Mentoring for its outstanding Physics Department. It was one of 17 institutions to receive an award through National Science Foundation's institution-wide reform of undergraduate education in science, math, engineering and technology program. Moreover, a study done at UCLA identified Bryn Mawr as one of just 11 institutions in the nation out of more than 200 studied to score at the highest level for demonstrated faculty commitment to teaching and research.

I am also very proud that the National Science Foundation has at its helm a very capable woman, Dr. Rita Colwell. I have certainly worked very closely with National Science Foundation on the shortage of women in the sciences for many years. The Foundation continues to be at the forefront of federal agencies committed to looking inward at our own workforce to fill our future high tech needs. And who do I have here from National Science Foundation? I know there are several people who are here. And I thank you very much for the work that you do. Not only here, but what you do back in Washington.

The Diversity Challenge

I think it is imperative that we understand the diversity challenge, and that we meet that challenge by learning and by practicing how to recruit and how to retain women in science, engineering and technology fields. We must also strengthen our national focus on how to attract and keep underrepresented minorities in the fields of math and science. You all know that I introduced legislation to investigate and make recommendations in these areas. But I want you to know I introduced it in an earlier legislative session before the bill actually passed. We first called it the WISE Tech Bill, which stood for Women in Science and Engineering. When the bill was finally considered in the Science Committee during the end of the 105th Congress, a number of years after it was originally introduced, it was expanded and we authorized it as the Commission on the Advancement of Women, Minorities and Persons with Disabilities in Science, Engineering and Technology (CAWMSET).

With funding from several federal agencies, the Commission met many times between April 1999 and July 2000. There were 11 members, nine women and two men, of which three were minorities. Eight members were from the corporate sector, one was from a nonprofit organization and two were educators. After four meetings, many subcommittee meetings, and the testimony of 115 leaders in business, government and education, the Commission released its report, *Land of Plenty, Diversity as America's Competitive Edge in Science, Engineering and Technology*. The members of the Commission may be good resources for you in different ways, and I found them all to be very willing to continue to help with moving forward beyond that report.

The report documents what we already know: women have historically been underrepresented in science and engineering occupations, and female and minority students take fewer high-level math and science courses in high school. [I know we've got some high-school teachers here who have a tremendous responsibility in terms of what they can do to inspire females.] It documents that female students earn far fewer bachelor's, master's and doctoral degrees in science and engineering than men. Of those women who have pursued higher degrees in math and science, they are more likely to teach part-time as opposed to work in research universities. Additionally, of women who do hold full-time positions at universities, they're rarely in high-ranking positions and they experience a substantial salary gap between themselves and their male counterparts. We also knew that women, who comprise almost 40 percent of our overall workforce, hold only 15 percent of the jobs in technical fields, and that seven out of 10 highly-skilled technical positions are held by white men, who make up about 40 percent of the workplace. And most importantly, we knew that these figures were unacceptable to fill our high-tech worker shortage.

We cannot remain dependent on recruiting foreign engineers and scientists. In 1999 we passed legislation to expand the ceiling for H1B visas from 65,000 to 115,000 people, and last year we raised the ceiling again to 195,000. I know that you are probably very familiar with The Third International Mathematics and Science Study or the TIMS Report. TIMS 1 and TIMS 2 compares the curricular experience and the achievement of students from over 50 different countries. In 1996, U.S. high-school seniors ranked among the lowest of the industrialized countries. The 1999 study recognized what we already knew, that the majority of African American and Hispanic students are isolated in schools that typically suffer from a grievous lack of resources. In that context, it is less surprising but no less unacceptable that African Americans and Hispanics, who make up 21 percent of the workforce, hold only 6 percent of STEM jobs. So we must ask the question: how can we supply the highly skilled workforce that America needs to remain competitive in a global economy?

Redressing Imbalances

The Commission concluded that redressing gender and racial imbalances in STEM is an economic and social imperative. Our increasingly diverse nation can only prosper on a broad foundation of human talent in order to maintain leadership in an increasingly global economy. The biggest challenge that the Commission faced was not establishing the facts, but understanding how certain stereotypes developed and creating recommendations of how to overcome patterns of racial and gender bias. The Commission was given four tasks:

- Focus attention on ways to eliminate artificial barriers to the recruitment, retention and advancement of those underrepresented groups in science, engineering and technology;
- Promote workforce diversity;
- Sensitize employers of the need to recruit and retain women and minority scientists, engineers, computer specialists;
- Encourage the replication of successful recruitment and retention programs by universities, corporations and federal agencies.

Knowing the complexity of the subject, the Commission's first recommendation is to adopt higher math and science standards, and at the state level, to train and retain better qualified teachers. There is, as you know, a shortage of teachers in these areas. The Glenn Commission was appointed as a result of the TIMS Report to look at what we can do in terms of math and science teaching. I served on that Commission. CAWMSET's work dovetailed with that of the Glenn Commission. CAWMSET members asked, what is being done with math and science as a result of the Glenn Commission? We subscribe to their recommendations of what must be done to enhance and expand competence and opportunity for further education for our math and science teachers.

The second area covered by the Commission's report was the education pipeline. We are losing girls from the math and science pipeline in elementary and middle school. Without female role models and mentors in this area, they do not envision their own success as a scientist, computer engineer or physicist. I had Bill Nye the Science Guy come before The House Science Committee, and we talked about the need to get women and minorities into STEM fields. And I said, "Mr. Nye, you know you're so popular, everybody knows about you, and you motivate interest in science. What would you think of the concept of Kate Sal, the Technology Gal?" He thought that was a great idea.

We do need more age-appropriate role models. We do need to look at these women who are at various points in the pipeline as the role models for those that follow. All of you are assuming this role in your own way. You are mentors whether you are teachers, whether you are graduate students, whether you are in the private sector. But we need to make you better known. We need to make sure that females know that these are professions that can be exciting, and that the doors are open for them. The role models that we have, yourselves included, carry a very heavy burden.

Eileen Collins was there via teleconference as the Commission rolled out its findings. She was the first woman to command a space shuttle mission in July 1999. She received an associate's degree from Corning Community College in New York in math and science before going to Syracuse for her bachelor's in math and economics. Had there not been that opportunity, she might never have been in the pipeline at all. Many others are more fortunate to be able to have a more direct opportunity, for instance here at Bryn Mawr, for that kind of education.

The Commission also acknowledged the shortage of leaders in science, engineering and technology by recommending a national campaign to raise awareness of successful women and minorities and individuals with disabilities in science, engineering and technology careers.

Where We Go From Here

Where do we go from here? An organization that I am very proud to be a part of has risen to the challenge of helping to fulfill some of the Commission's recommendations. A coalition of nine federal agencies, led by the National Science Foundation, has provided seed funding of $2.2 million to establish a public/private partnership to carry on the work of the Commission. The new partnership will be called BEST, an acronym for Building Engineering and Scientific Talent. It will spearhead a three-year national campaign by establishing itself as the nation's hub for identifying and sharing best practices in building a stronger, more diverse technical workforce. BEST will be a resource for any institution or community in the country that wishes to meet the diversity challenge. BEST is still in its formative stages but is moving ahead pretty quickly. It will be based in San Diego, but it will have partnerships with federal, private and public organizations around the nation. It will be doing a lot of work in the Washington, D.C. environs, which would include Philadelphia.

Let me tell you a little bit more about this Building Engineering and Scientific Talent organization. I mentioned federal support coming from nine federal agencies. They are the National Science Foundation, National Institutes of Health, NASA, Department of Agriculture, Department of Defense, National Institute of Science and Technology (NIST), Department of Energy and Department of Education. It has a national advisory board, and I am one of the co-chairs of that national advisory board with Congresswoman Eddie Bernice Johnson (D-Texas), who currently chairs the Congressional Black Caucus and serves with me on the House Science Committee. Other members include Marty Evans, president of the Girl Scouts; John Slaughter, president of the National Action Council of Minorities in Engineering; Bruce Alberts, president of the National Academy of Sciences; and Bill Wulf, president of the National Academy of Engineering. There will be three blue-ribbon panels that will be convened to produce national best practices in higher education. Some of the prominent women whom you have probably heard of — again, those role models — will be part of those. Shirley Ann Jackson, president of Rensselaer Polytechnic Institute, is chairing one of these panels. Dr. Jackson is a theoretical physicist; a former research scientist at AT&T Bell Laboratories; a former professor at Rutgers; a former chair of the Nuclear Regulatory Commission; a life member of the MIT Corporation; a member of the National Academy of Engineering; and the first woman to win the Black Engineer of the Year Award. Carol Muller, founder and executive director of MentorNet, the national electronic mentoring network for women in engineering and science, will chair another panel. She is also a consulting associate professor of engineering at Stanford. Lilian Shaio-Yen Wu, who chairs the National Research Council's Committee on Women in Science and Engineering, will chair the third panel. Dr. Wu is an applied mathematician, a technical consultant at IBM, and a past member of the President's Council of Advisors on Science and Technology.

This national initiative is an enormous challenge, but it is a necessary one. For example, we know that many more women complete high school with the skills to pursue technical careers than actually do. Limiting factors that come into play starting in grade school, continuing through higher education and into the workplace, create a variety of barriers. The net result is that women are generally and greatly underrepresented in our technical workforce, and our workforce is weaker for it. The challenge I mentioned is even more profound for African Americans, Hispanics and Native Americans. And many of these groups don't even acquire the basic skills in K-12 to pursue technical careers.

So it is going to take leadership on the part of the government, industry and educators to meet the diversity challenge. And I would also stress the fact that industry must rise to this diversity challenge. We need more CEOs who are engaged in improving K-12 education, whose companies are mentoring women and minorities in college, and who believe in strengthening their companies through diversity. I see the role of educators as also very critical in this equation. Reaching out to women and other underrepresented minorities in science, engineering and technology can make all the difference in a student who is interested but not confident.

Education as always is a key to our preparedness in math and science. And that happens at institutions of higher education such as Bryn Mawr. Now, Amy Lowell — I draw here on my history as teacher of English — Amy Lowell wrote a poem that is a rather lengthy one called “Sisters,” and I just remember at one point as a poet she was looking back at whom she could look to for the advice, for the inspiration, for the experience from which she might gain. And she looked at Sappho and Elizabeth Barrett Browning, Edna St. Vincent Millay and Emily Dickinson, and realized that although they were all women, each reflected a different sociohistoric context and thus faced different kinds of barriers, and wrote in different styles. But what they had in common is that they were women who had to transcend certain barriers to succeed as poets.

So at the end of the poem Lowell writes, “I hope that someday, somebody who thirsts to write will look upon me as I have looked upon you my sisters.” And for you as women in science, engineering and technology, I think you are able to say the same thing as you look at Florence Nightingale, Elizabeth Blackwell, Mary Edwards Walter, Marie Currie, and more contemporary women such as Sally Ride and Rita Colwell. I hope that someday some woman who thirsts to have contributed something in science, engineering and technology will look upon me as I have looked upon you. We are sisters.

Profiles of Participants

Lisa Bievenue is the K-12 lead for the Education, Outreach and Training Partnership for Advanced Computational Infrastructure (EOT-PACI) and Education Program Coordinator at the National Center for Supercomputing Applications, University of Illinois at Champaign-Urbana. Her current research interests include the use of computer-based modeling and scientific visualization to promote learning, and professional development programs to support the use of technology in the classroom. She is currently pursuing a Ph.D. in Education at the University of Illinois, where she earned her B.S. and M.A. degrees.

Amy Bug, Associate Professor of Physics at Swarthmore College, conducts research on computational chemical physics. She received a Ph.D. from the Massachusetts Institute of Technology and has conducted postdoctoral research at Exxon and Columbia University. Dr. Bug is a member of Sigma Xi, the American Physical Society, the Council on Undergraduate Research and the Neutron Scattering Society.

Catherine (Kitty) Didion is the Executive Director of the Association for Women in Science, which is dedicated to achieving equity and full participation for women in science, mathematics and engineering, working through a national office and 74 local chapters. AWIS has produced several major publications including *A Hand-Up: Women Mentoring Women in Science*, *Grants at a Glance*, and *Taking the Initiative (Proceedings of a Leadership Conference for Women in Science and Engineering)*. As Executive Director of AWIS, Ms. Didion has written about women and science for *The Scientist* and *Science and Initiatives*, has testified before Congressional committees, national commissions and other major government task forces, and has spoken in a variety of professional forums. She is currently the Chair of the Environment and Science Task Forces for the Coalition for Women's Appointments, and is co-principal investigator on several NSF grants.

Julie Sheridan Eng '88 is Director of New Product Development at Agere Technologies. She chairs the IEEE Committee on Women in Engineering's subcommittee on governmental and public policy, and was Chair of the WIE committee from 1997-98. She received her Ph.D. from Stanford University.

Natalie Feilchenfeld '79 is Technical Team Leader for Silicon and Germanium Technology Development at IBM Microelectronics. She has worked in a variety of areas including packaging (polymer and photolithographic materials processing) and in semiconductor development (SiGe and BiCMOS technology development) with IBM Microelectronics, which she joined in 1985. She received her Ph.D. in chemistry from Carnegie-Mellon Unievrsity and has done postdoctoral work at the University of Chicago.

Suzanne E. Franks is Director of the Women in Science and Engineering Program at Kansas State University. She holds a Ph.D. in biomedical engineering from Duke University and has additional training in women's studies and secondary education. Dr. Franks has worked in basic cancer research in the United States and Germany, and as a medical writer and manager in the pharmaceutical industry. At Kansas State University, she leads the development of recruitment and retention programs for women in engineering and science from middle school through postgraduate levels.

Susan Graham is Director of New Business Development in the Adhesives and Sealants Division of Rohm & Haas Company. She has held executive positions at American Cyanamid, Ashland, National Starch, Reichhold and Rohm & Haas, where she currently directs portfolio management, strategic planning and e-commerce design for a $700-million business division. A strong advocate of networking as a means to support the advancement of women in industry, Dr. Graham has been recognized for her mentoring work with young women interested in the sciences.

Priscilla Perkins Grew graduated from Bryn Mawr as a geology major in 1962. She is currently a professor of geosciences at the University of Nebraska. Professor Grew is a recipient of the American Geological Institute's Ian Campbell Medal and was the first woman to head the California Department of Conservation, chair the state's Mining and Geology Board, direct the Minnesota Geological Survey and serve as the Vice Chancellor of Research at the University of Nebraska-Lincoln.

Paul Grobstein is the Eleanor A. Bliss Professor of Biology and Director of the Center for Science in Society at Bryn Mawr College, which he joined in 1986. A neurobiologist, developmental biologist and educator, he conducted postdoctoral research at Johns Hopkins University and Stanford University. Dr. Grobstein has published more than 50 journal articles and book chapters on nervous system development, brain organization and function in relation to behavior, and theoretical biology. He has a long-standing interest in science education and continues to be actively involved in secondary-school teacher education and minority outreach programs.

Jong-On Hahm is Director of the Committee on Women in Science and Engineering at the National Research Council. Prior to joining the NRC, she held a faculty appointment in the department of neurosurgery at Georgetown University Medical Center. Previously, Dr. Hahm held postdoctoral appointments at the National Cancer Institute and the National Institute of Mental Health. She has a Ph.D. in neuroscience from the Massachusetts Institute of Technology.

Janice Hicks '80 is Program Director in Analytical and Surface Chemistry at the National Science Foundation. She became the Clare Booth Luce Assistant Professor of Chemistry at Georgetown University in 1989, and established a research group on the applications of lasers to surface science. Dr. Hicks earned her Ph.D. at Columbia University, where she received the George P. Pegram Distinguished Fellowship in the Natural Sciences. She was a Postdoctoral Fellow at the University of Pennsylvania, a Presidential Young Investigator, a Sloan Fellow and Visiting Professor at Albert Einstein College of Medicine. She has been at the NSF since 1999.

Toby Horn '71 is a consultant with the District of Columbia Public Schools — DC ACTS. A chemistry major at Bryn Mawr College, she earned a Ph.D. in biology at the University of Colorado, completed postdoctoral studies at Johns Hopkins University and was a cancer researcher at the National Institutes of Health. Dr. Horn started some of the first biotechnology programs for high-school students as Director of Community Outreach at the Fralin Biotechnology Center, Virginia Tech University.

Jane Butler Kahle is Condit Professor of Science Education at Miami University and recently served as Director, Division of Elementary, Secondary and Informal Education at the National Science Foundation. Dr. Kahle is an international scholar in gender differences in science education and the evaluation of the systemic reform of science and mathematics education. She has led systemic reform of science and mathematics education in Ohio for the past nine years and consults nationally with school districts. She also chaired The National Science Foundation's Committee on Equal Opportunity in Science and Engineering, a Congressionally-mandated committee that reviews on a biannual basis what is happening within NSF.

Maria-Luisa Maccecchini was until recently President and CEO of Annovis Inc. She has more than 20 years of experience in new product discovery, development and commercialization in the pharmaceutical and biotechnology industries. She founded Symphony Pharmaceuticals in 1993, which became Annovis with the acquisition of Cruachem Holdings Ltd. Annovis produces novel nucleic acids that are used in the analysis of the human genome and the discovery of new drugs and diagnostics. In 2001, Annovis was acquired by Transgenomic Inc.

Elizabeth F. McCormack, Associate Professor of Physics, joined Bryn Mawr College in 1995. She was a Fulbright Senior Research Scholar Fellow at the University of Paris XI, a guest scientist at the Paul Scherrer Institute in Switzerland and a consultant in developing a physics curriculum at Effat College, a new science college for women in Jeddah, Saudi Arabia. A member of the American Physical Society, the American Association of Physics Teachers, the Association for Women in Science and Project Kaleidoscope, Dr. McCormack has authored more than 20 journal articles. She earned a Ph.D. in physics at Yale University.

Rebecca Mercuri, Assistant Professor of Computer Science, joined Bryn Mawr College in 2001. Her research focuses on multimedia interactive programming, computer science and security risks, and electronic voting. Dr. Mercuri has testified before the House Science Committee on voting system standards, consulted for the General Accounting Office on Internet voting, and has prepared detailed comments on a proposed new standard of the Federal Election Commission. She earned her Ph.D. in computer and information science at the University of Pennsylvania, and is a member of the New York Academy of Sciences.

Representative Connie Morella (R-Md.) has focused her legislative efforts on scientific research and development, education, the federal workforce, equity for women and the environment. In 1998 she authored legislation establishing the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology, and continues to support efforts to increase the representation of women, minorities and people with disabilities in the sceince and technology workforce.

Maria Pellegrini is a Program Director at the W.M. Keck Foundation and former Professor of Biology and Dean of Research, College of Letters, Arts and Sciences, University of Southern California. She has taught a variety of courses in molecular biology and biochemistry at the undergraduate and graduate levels. Dr. Pelligrini's research focuses on structure-function relationships within ribosomes, regulation of ribosomal gene expression, and genes involved in human reproduction.

Lori Perine ’80 is CEO of Interpretech LLC and former Deputy to the Associate Director, Technology, White House Office of Science and Technology Policy. She has broad experience in forging strategic partnerships and developing initiatives for advanced technologies within government, industry, academia and international organizations. At OSTP, Dr. Perine oversaw national technology policy and large-scale research initiatives, specializing in information technology applications, technology innovation and commercialization, global competitiveness, and math and science education. She previously served with the U.S. Department of Commerce, the National Institute of Standards and Technology, and the World Bank.

J. Pari Sabety ’77 is the Director of the Technology Policy Group at the Ohio Supercomputing Center, which focuses on the legal and policy challenges that arise with the deployment of new computing and network technologies. She has a decade of experience in building technology-led economic development strategies in communities across the United States. Ms. Sabety co-founded a consulting firm with former Ohio Governor Richard F. Celeste, which managed research projects for corporate clients, and served as Celeste’s policy adviser on economic development.

Maxine Savitz ’58 is a Member of the National Academy of Engineering and the National Science Board, and former Director of Technology Partnerships at Honeywell Corporation. She has broad and deep experience across the university, government and corporate sectors. Dr. Savitz has served on the faculty of the University of the District of Columbia, directed divisions of the U.S. Department of Energy, and held executive positions at the Garret Corporation, Allied Signal and Honeywell.

Jill T. Shapiro Sideman earned her M.A. in 1963 and her Ph.D. in 1965 in physical and organic chemistry at Bryn Mawr. She went on to conduct research in high-energy physics and molecular biology as a fellow of the National Bureau of Standards, the National Institute for Arthritis and Metabolic Diseases, the Institut Pasteur in Paris and the University of Washington Medical School. In 1974 she co-founded the environmental consulting firm of Shapiro and Associates, a standard-setter in the fields of environmental impact, analysis, wetlands and coastal zone management, and energy conservation. In 1986 she joined the international engineering firm of CH2M HILL, where she is a Vice President and Director. In recent years she has given leadership to national efforts to diversify the science and engineering workforce, serving, for example, as a member of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology (CAWMSET). Dr. Sideman is currently President of the Association of Women in Science, the largest multidisciplinary scientific organization for women in the United States.

Anne M. Thompson is an astrophysicist at the Atmospheric Chemistry and Dynamics Branch of NASA’s Goddard Space Flight Center. She studies tropospheric ozone and its relationship to natural processes and global change. A pioneer in the use of multi-satellite data sets to view the earth as a system, Dr. Thompson coordinates SHADOZ, an 11-nation network for ozone sounding that is the basis of satellite validation and regional air-quality studies and education in the host countries there as well. She has authored more than 100 science publications since receiving her Ph.D. in physical chemistry from Bryn Mawr College in 1978.

Nancy J. Vickers joined Bryn Mawr as the College's seventh President in 1997. A scholar in the fields of literary and cultural studies, her interests range from Renaissance poetry to the transformation of the lyric genre as a result of new technologies such as music video and television. She served on the faculties of the University of Southern California and Dartmouth College, and has been a visiting professor at Harvard University, the University of Pennsylvania and the University of California, Los Angeles, and a visiting fellow at Princeton University. Dr. Vickers earned a Ph.D. in Romance Languages from Yale University.

William Wulf, President of National Academy of Engineering, has authored more than 100 articles, technical reports and books. He is currently on leave as professor at the University of Virginia. His research spans computer architecture, security, programming languages and optimizing compilers. The National Academy of Engineering, together with the National Academy of Sciences, is chartered by Congress to provide advice to the government on issues of science and engineering.

Kim Ann Zajack is Director of Pre-College Programs, The Douglass Project for Rutgers Women in Math, Science and Engineering, Rutgers University. She is a former educator and adviser in agribusiness and agriscience technology. She has served as an international consultant on agricultural education in Russia and the Ukraine, as Program Associate in Cooperative Extension for Community Outreach at Cook College, and as Agricultural Education Specialist at the New Jersey Department of Education.

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