MAKING STRIDES

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American Association for the Advancement of Science (AAAS)

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Inside this issue:

Reflecting America?: Immigrants, Minorities and Women in the S&T Workforce[1]

By Dr. Charlotte Kuh, Executive Director, Office of Scientific and Engineering Personnel, National Research Council

I have been asked to discuss the current state of diversity in the science and technology workforce, including immigrants. Whereas numbers are my usual domain, I would like to spend my time here talking about philosophy.

The philosophical question I wish to discuss is what is underrepresentation? How do we recognize it when we see it? And, more fundamentally, why does it matter? If we were to say that the science and engineering workforce should reflect the American population, what would the operational significance of that statement be?

Here's a simple (and easy) example. Women make up slightly more than half of the American population. They are more than half of baccalaureate degree recipients. They are somewhat less than half of the labor force. They are 33 percent of S&E doctoral degrees, but still only 22 percent of the S&E labor force. Is there something wrong here? Are women underrepresented? The S&E workforce is becoming feminized but, particularly in the physical sciences, math sciences, and engineering, it doesn't reflect America at all.

We know that, failing a major military engagement or a revolution in family planning, the share of women in the population is unlikely to change much. So we can ask, is 22 percent a number we should worry about? I would argue that it is, both from the viewpoint of science and engineering as disciplines, and from the viewpoint of society as a whole. Science and engineering are impoverished if, for social and cultural reasons, these disciplines deny themselves the very best talent. Science and engineering are poorer for the absence of a woman who might have a fundamental insight or develop an especially clever device. From the point of view of society, we must never forget that women vote. If women are convinced that science and engineering are irrelevant to their world, then support of science and engineering is quite likely irrelevant to their preferences—and has a lower status on the public agenda as a result. Finally, families being what they are, women play a key role in informal education—they are mothers. To the extent that they feel that science and engineering are "hard" and "incomprehensible," that view is inculcated in our children—and science and engineering lose both men and women as a result. I find it remarkable that the share of science and engineering in baccalaureate degrees remains constant at around one third, even as our economic growth depends increasingly on the products of scientific and engineering research. This may be partially the result of a generally held view that science is difficult—and many of our mothers were convinced that it was.

The same arguments hold for ethnic diversity, except more so. The American population is becoming more and more ethnically diverse. We deny ourselves talent if we believe that only white males can do science. Society loses commitment to science if

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From the Editors:

This issue of Making Strides features an interview with the co-recipient of the 2000 AAAS Lifetime Mentor Award, Dr. Evelyn Hu from the University of California at Santa Barbara. Dr. Hu has mentored more than 40 underrepresented minority and women students through engineering degrees. She shares with us the secrets behind her accomplishments and insights on how programs can more successfully recruit and maintain top-level underrepresented minorities and women in science and engineering programs.

In our lead article this month, Charlotte Kuh, executive director of the Office of Scientific and Engineering Personnel at the National Research Council, discusses the consequences of the underrepresentation of women and minorities in science and engineering fields. Yolanda George, Virginia Van Horne, and Shirley Malcom report on first-year graduate student enrollments in Research I universities. While the numbers of underrepresented minorities beginning graduate programs has increased since 1997, they are still far below 1996 levels. Finally, Lenell Allen shares with us the structure of the Missouri Alliance for Graduate Education and the Professoriate (MAGEP) Program.

Our next issue of Making Strides, will include a report on the AGEP meeting held last fall at AAAS Headquarters in Washington, DC. The meeting featured lively discussions on the future of research and the implementation of programs designed to meet the goal of diversifying the professoriate. In addition, we will have an institutional profile of the Colorado AGEP program, reports on new research being done on diversity in graduate education and academia, and an interview with a professor who is making a difference in the fields of science, mathematics and engineering by encouraging and mentoring students.

Let Us Know What You Think

Please continue to send us your comments, feedback and inquiries. The goal of this newsletter is, after all, to serve the needs of its readers. If you are interested in submitting a research article, please contact Jolene Jesse at jjesse@aaas.org. For further information about our work, visit http://ehrweb.aaas.org/mge/.

science remains the domain of white males, even as our society becomes more diverse.

These are generic arguments for reaching out to make science more inclusive. They don't speak to the question of over- or under-representation. But there is no reason to think that a desirable distribution is uniform, with every group being represented according to its proportion in the population. With women, for example, you would expect some inequality if women are more likely to take time out to have children. We would expect more women in those occupations that permit part-time or interrupted careers. For some minority groups, economic inequality might generate a preference for occupations with a higher economic return. It is difficult to object to someone from a poor family preferring to become a medical doctor rather than a biochemist. It is understandable that such a person might choose a career in business rather than in academia. What we are trying to remedy is inequality of opportunity. We do not ask for equality of results.

There is very little blatant discrimination these days. The MIT report on women faculty in the Science Division[2] found that what rankled most were systematic differences in resources: space, teaching loads, and summer money. Further, there was underrepresentation of women in administrative positions (e.g., department chair) that control resources. The problem was not the "old" discrimination of sexist remarks or discriminatory hiring practices. In fact, many of the women would have preferred not to take on administrative duties. They'd rather spend their time doing science. Because women didn't want to take on positions that would give them less time to do science—and, as a result, found themselves in a less strong negotiating position for academic perks—is something discriminatory going on?

How can you tell if there is underrepresentation, given that what we observe is results not opportunity? There is a report that should be coming out in 2001 that looks at differences in a variety of career outcomes for men and women Ph.D.s in science and engineering. One of the techniques used in the report is to estimate logit regressions in which a particular outcome, such as being tenured, depends on virtually everything that can be measured, both demographic measures and career and education characteristics. It turns out that years of experience since the Ph.D. explain a considerable amount of the difference in outcomes between men and women and that difference results from time spent raising children. Are women underrepresented among tenured faculty? Yes. But if underrepresentation of women can be explained by a different pattern of work/family choice than men, is it a cause for concern and policy development? I would argue that it should be—that the scientific workplace should be more flexible and family friendly. But we don't know if more American women would choose to do science and engineering even if the workplace were more family friendly.

These are difficult questions and they get at the difficulty we encounter when we say a group is "underrepresented." I tried one other way to get at differential representation. The notion underlying my approach is the idea of a role model. As is apparent from the numbers you have seen, the scientific workforce is more diverse today than it has ever been. But it still isn't very diverse and, especially for women in engineering and the physical sciences and for underrepresented minorities in all fields, it isn't diverse at all. I have created a measure of this. For women, it is a measure of how many graduates there are in a field per faculty member. It is a rough measure of the chance that a member of a particular group may have seen a faculty member in their field that belongs to the same group. It has something to do with the ease with which a student can say, "Yes, there I am ten years from now!" The more constricted the pipeline is at the top, the greater this ratio will be. As can be seen in Figure 1, this ratio, even in 1996, is unambiguously greater for women than for men in all fields. I should add that this measure isn't about mentoring. Mentoring is about a relationship and may depend as much on intellectual similarity as on gender or ethnicity. Hopefully, the pool of potential mentors is greater than the pool of women faculty or it will be an uphill battle to increase the

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representation of women in fields in the physical sciences and engineering.

In the case of minorities, there are so few faculty members from some groups in some fields that I can't construct the same measure with publicly available data. So, in Figure 2 I've constructed the ratio of bachelor's degrees to total Ph.D.s. Again, there are much higher ratios for underrepresented minorities than for whites and, in some fields, Asian-Americans. This disparity has two implications: 1) minority students are much less likely to find people who look like them in the scientific work force; and 2) minority faculty may find that they face much higher demands to mentor and encourage minority students than do their white counterparts. This makes even more imperative the need to expand mentoring of minority students beyond minority faculty.

The lesson to take home about this measure is that increasing diversity in science and engineering must be everybody's job. There are simply not enough women faculty or minority Ph.D.'s to rely on within group bootstrapping. We need to identify those places where women and minorities thrive and direct them there. Especially in the case of underrepresented minorities, there are too few not to treat each person as special and worthy of encouragement.

You will notice that "immigration" is in my title and I haven't talked about it yet. The National Research Council recently completed a study on the information technology (IT) workforce that addresses this issue directly.[3] In a tight labor market, such as the market for information technology workers, immigration can help ease shortages with highly skilled scientists and engineers who have been trained abroad. The availability of these workers may have some depressing effect on the wages of U.S. workers,[4] but they are hired because of the shortage of American workers with IT skills. Rather than supporting a hypothesis that the presence of foreign students deters American students from studying science and engineering, it is more likely that foreign students and workers are brought in *because* we have too few American students and workers in science and engineering fields. Thus, the need to increase participation of women and underrepresented minorities in science and engineering is made all the more urgent.

I would also like to call your attention to the work of Richard and Greg Attiyeh, who found that it was considerably more difficult for non-US citizens to be admitted to graduate school than for US citizens, controlling for GRE scores.[5] The 1997 paper by Espenshade and Rodriguez found that slightly higher proportions of non-U.S. Ph.D. students completed their doctoral degrees and in less time than their U.S. counterparts.[6] I have used the NRC assessment of research doctoral programs to see if

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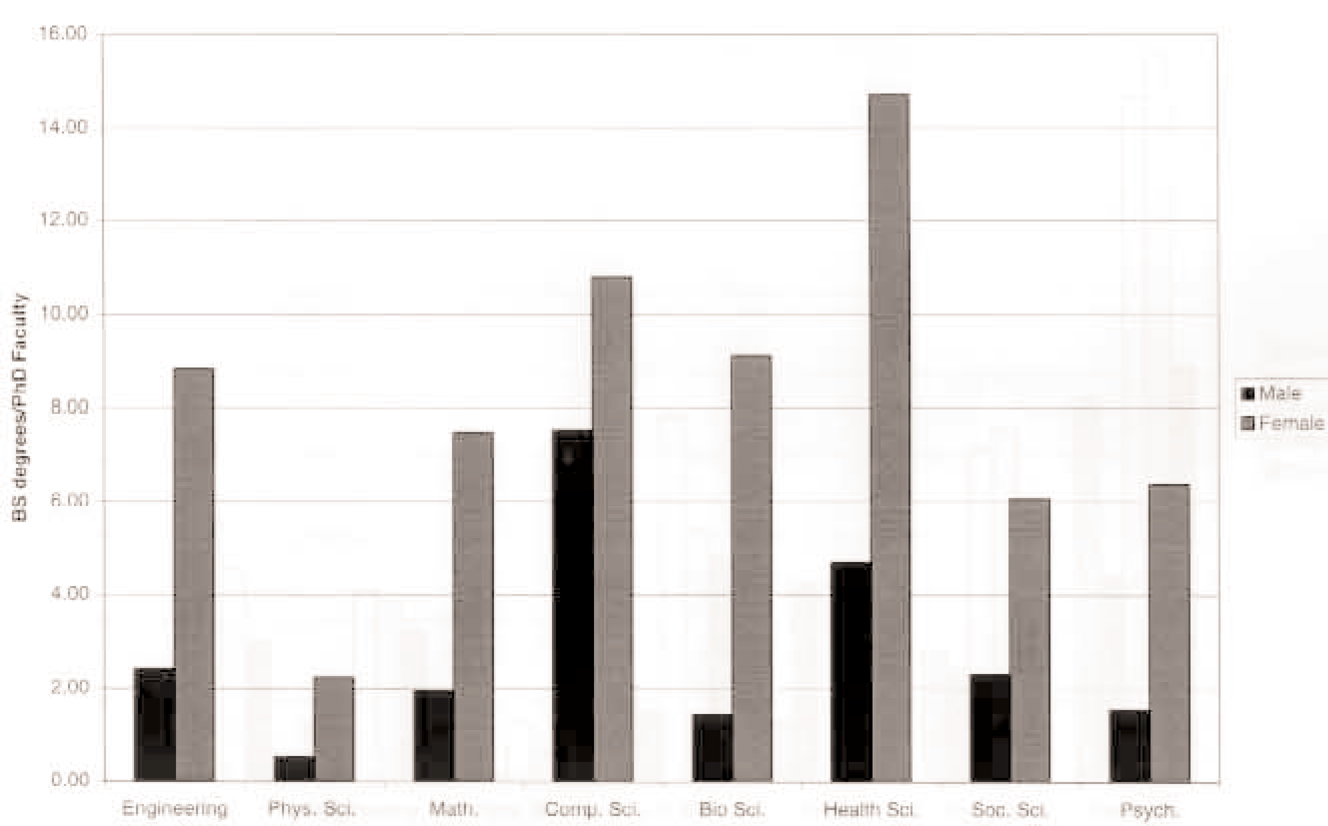
Figure 1. BS/Faculty ratios by gender



SOURCE: National Science Foundation/Division of Science Resources Studies, 1997 Survey of Doctorate Recipients.

there are differences in the quality of programs with higher proportions of international students within a field and find that the better programs all graduate about the same percentage of international Ph.D.s. For less distinguished programs, the proportion of non-U.S. citizens ranges from 0 to 100%—essentially random. I find it very unlikely that graduate programs are denying places to U.S. minorities in favor of international students.

To conclude, I feel quite strongly that the U.S. needs more people to do science and engineering at most levels. The news about a bad academic job market for Ph.D.s shouldn't disguise the overall need for scientific literacy and the ability to apply analytic reasoning to many problems in the workplace. We are not yet good at bringing underrepresented minorities into science and engineering. Getting better will involve identification of what works and commitment to implementing it at all stages of the educational process. If we can do that, I think we can build a science and engineering workforce that will reflect America.

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[1] This piece is adapted from a presentation given at the AAAS 2000 Annual Meeting, February 18, 2000, and published in *Scientists and Engineers for the New Millennium: Renewing the Human Resources*, The Commission on Professionals in Science and Technology, March 2001. The views expressed herein are those of the author alone.

[2] *A Study on the Status of Women Faculty in Science at MIT*. MIT, 1997 in the *MIT Faculty Newsletter*, vol. XI, no. 4; March, 1999.

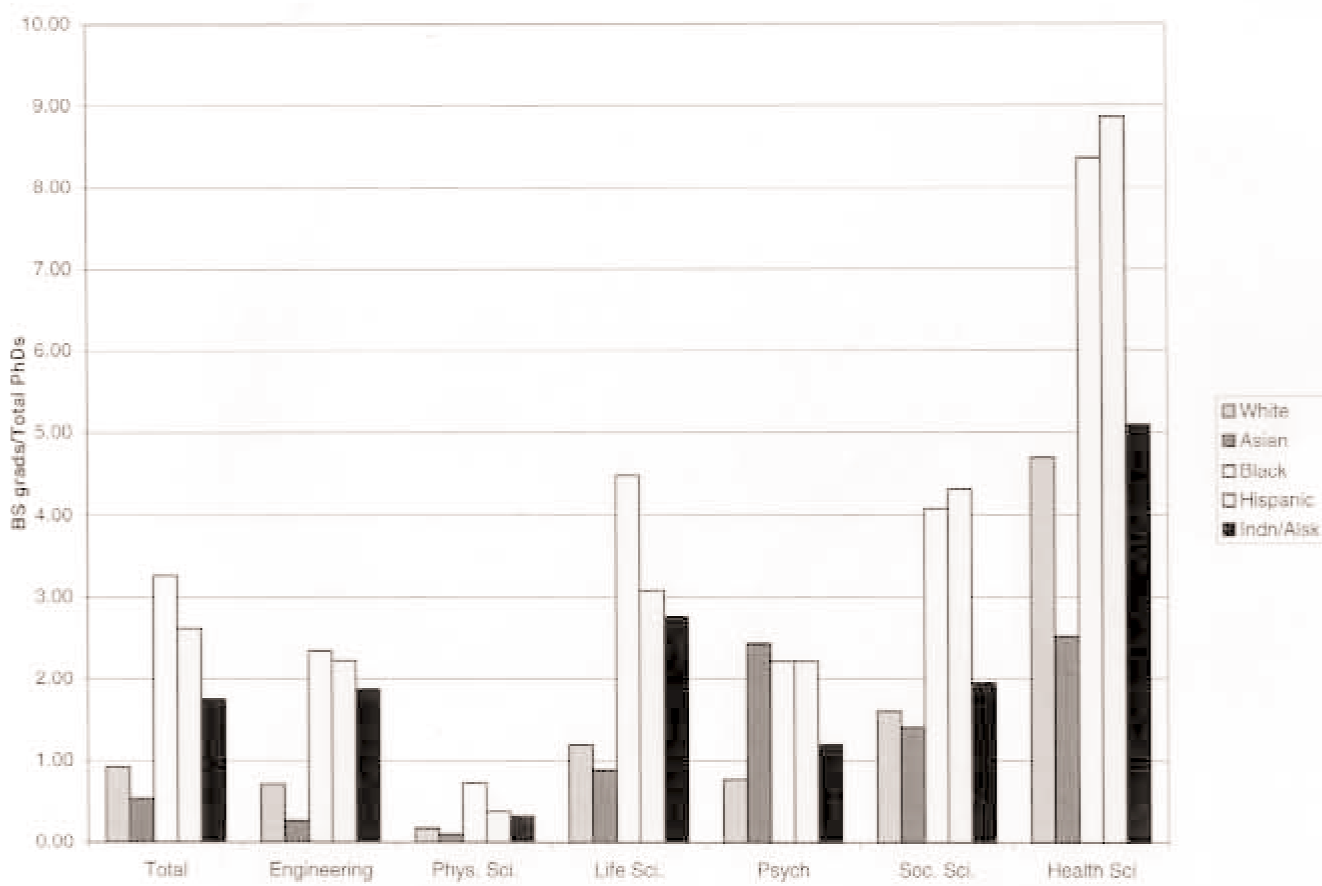
[3] *Building a Workforce for the Information Economy.* Washington, D.C.: National Academy Press, 2001.

[4] Another NRC committee estimated that a 10% increase in immigrant workers, depressed U.S. wages by about 3%, but this estimate was for workers generally, not highly skilled workers. *The New Americans: Economic, Demographic, and Fiscal Effects of Immigration.* Smith, James P., and Barry Edmonston, eds. Washington, D.C.: National Academy Press, 1997.

[5] Attiyeh, G. and Attiyeh, R. "Testing for Bias in Graduate School Admissions." *Journal of Human Resources*. 32(3):524-548.

[6] Espenshade, T. and Rodriguez, G. "Foreign Graduate Students in U.S. Doctoral Programs." Office of Population Research Working Paper, Princeton University, 1997.

Figure 2. BS grads per Total PhD's by Race/Ethnicity
1996-97



SOURCE: National Science Foundation/Division of Science Resources Studies, 1997 Survey of Doctorate Recipients.

Making Strides?: Graduate Enrollment of Underrepresented Minorities in Science and Engineering[1]

By Yolanda S. George, Virginia V. Van Horne and Shirley M. Malcom
American Association for the Advancement of Science (AAAS)

Introduction

Since 1996 a wave of judicial rulings, legislative referenda, and editorial opinions opposing affirmative action has swept across the United States. Given this context, in 1997-98, an AAAS study found a precipitous drop in the first-year graduate school enrollment of African American and Hispanic students in all science and engineering fields between 1996 and 1997 in Research I universities. These findings were reported in *Losing Ground: Science and Engineering Graduate Education of Black and Hispanic Americans* by Shirley M. Malcom, Virginia V. Van Horne, Catherine D. Gaddy, and Yolanda S. George, 1998. The objective of this study is to determine if the changing climate for affirmative action is continuing to affect the first-year graduate school enrollment of underrepresented minorities in science and engineering in Research I universities.

Methods

AAAS staff surveyed 76 Research I universities with both high levels of R&D expenditures and significant graduate education programs. Universities were asked to provide numbers for first-time (new) graduate student enrollees (full and part-time) for 1994-95, 1995-96, 1996-97, 1997-98, and 1998-99 by schools or departments in computer sciences, engineering, mathematics, natural sciences, psychology, and social sciences. Numbers were requested for total number of students and total U.S. citizens and permanent residents by gender and race. Of the 65 respondents, 42 or 64.6 percent were able to provide data disaggregated by race. Of these 42 respondents, 30.9 percent were located in the South, 26.2 percent in the West, 23.8 percent in the East and 19.2 percent in the Midwest. The 42 respondents represent 48 percent of all Research I universities.

Key Findings

From 1994 to 1998, the percent of first-year graduate student enrollment in selected Research I universities in all fields of science and engineering for U.S. citizens and permanent residents continued to decrease, although the absolute numbers increased (Table 1). However, the number and combined percent of first-year graduate student enrollment of U.S. citizens and permanent residents in computer sciences, engineering, mathematics, and natural sciences decreased from 1994 to 1997, while the percent remained stable for 1997 and 1998, and the absolute numbers increased (Table 2).

The first-year graduate student enrollment in selected Research I universities in computer sciences, engineering, mathematics, and natural sciences for U.S. citizens and permanent residents rose 14.4 percent from 1997 to 1998 and was 1.6 percent above 1996 enrollment. However, while the first-year graduate student enrollment in computer sciences, engineering, mathematics, and natural sciences in selected Research I universities for underrepresented minorities (African Americans, Hispanic Americans, and American Indians) rose 16.4 percent from 1997 to 1998, it was 6.8 percent below the 1996 enrollment (Table 3). Although the first-year graduate student enrollment in computer sciences, engineering, mathematics, and natural sciences in selected Research I universities for African Americans rose 22.7 percent from 1997 to 1998, it was 8.1 percent below the 1996 enrollment (Table 3).

The first-year graduate student enrollment in computer sciences, engineering, mathematics, and natural sciences in selected Research I universities for Hispanic Americans rose 13.2 percent from 1997 to 1998, but it was still 6.5 percent below the 1996 enrollment (Table 3).

While the first-year graduate student enrollment in all fields of science and engineering in selected Research I universities for US citizens and permanent residents rose 11.8 percent from 1997 to 1998, it was 3.4 percent below the 1996 enrollment. However, while the first-year graduate student enrollment in all fields of science and engineering in selected Research I universities for underrepresented minority students (African Americans, Hispanic Americans, and American Indians) rose 9.0 percent from 1997 to 1998, it was still 13 percent below the 1996 enrollment (Table 4).

First-year graduate student enrollment in all fields of science and engineering in selected Research I universities for African Americans rose 15.7 percent from 1997 to 1998, but it was still 10.2 percent below the 1996 enrollment (Table 4).

From 1997 to 1998, first-year graduate student enrollment in all fields of science and engineering in selected Research I universities for Hispanic Americans rose 2.4 percent, however this was still 17.7 percent below the 1996 enrollment (Table 4).

While first-year graduate student enrollment for US citizens and permanent residents in selected Research I universities rose for all

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[1] This piece is published in *Scientists and Engineers for the New Millennium: Renewing the Human Resources,* The Commission on Professionals in Science and Technology, March 2001.

fields from 1997 to 1998 it was still below 1996 enrollments in psychology (-34.5 percent), in engineering (-10.1 percent), and in social sciences (-6.7 percent) (Table 6).

Although first-year graduate student enrollment for underrepresented minorities (African Americans, American Indians, and Hispanic Americans) in selected Research I universities rose for all fields from 1997 to 1998, it was still below 1996 enrollments in psychology (-24.2 percent), engineering (-21.9 percent), social sciences (-10.5 percent), and natural sciences (-1.6 percent) (Table 7).

For African Americans, first-year graduate student enrollment in selected Research I universities between 1996 and 1998 remained the same in mathematics and about the same in the natural sciences. It was still below 1996 enrollments in engineering (-22.3 percent), social sciences (-12.5 percent), psychology (-12.2 percent), and (-10.4 percent) in computer sciences (Table 8).

For Hispanic Americans the first-year graduate student enrollment in selected Research I universities between 1996 and 1998 rose in computer sciences and mathematics. It was still below 1996 enrollments in psychology (-37.9 percent), engineering (-22.6 percent), natural sciences (-4.5 percent), and social sciences (-10.5 percent) (Table 9).

Conclusions

Given the 1998 to 1999 rebound for first-year graduate school enrollment of underrepresented minorities in science and engineering in selected Research I universities, it appears that the anti-affirmative action climate in the United States is one of several factors that negatively affected 1997 to 1998 enrollments. Since a significantly higher number of underrepresented minorities enrolled in graduate schools in Research I universities for the first time in 1998 to 1999, it is likely that university administrators and faculty were sorting out what admission practices were appropriate and/or legal and possibly putting forth more effort in terms of recruitment.

However, first-year graduate school enrollment in engineering in selected Research I universities for U.S. citizens and permanent residents, particularly underrepresented minorities, was still below the 1996 enrollment, perhaps due to the strong job market in these fields. The 1998 enrollment of first-year graduate school students in psychology was also far below the 1996 enrollment. In addition, the 91 percent increase in Hispanic enrollments in mathematics from 1996 to 1998 should be noted.

For more information and continuing updates on minority graduate education see the *Making Strides–In Search of Structural Reform in Science, Mathematics, and Engineering Graduate Education and the Professoriate*, *http://ehrweb.aaas.org/mge/.*

Table 1—Number and Percent of First-year Graduate Student Enrollment in Selected Research I Universities in Computer Sciences, Engineering, Mathematics, Natural Sciences, Psychology, and Social Sciences (*All Fields of Science and Engineering*) for 1994-95 to 1998-99, N=42

Year	Total Number of Graduate Students	Total US Citizen & Permanent Residents	Underrepresented Minorities*	African Americans	Hispanic Americans
1994	26,937	19,282 (71.6%)	2,180 (8.1%)	1,285 (4.8%)	790 (2.9%)
1995	26,261	18,648 (71.0%)	2,056 (7.8%)	1,209 (4.6%)	758 (2.9%)
1996	26,631	18,374 (69.0%)	2,125 (8.0%)	1,191 (4.5%)	836 (3.1%)
1997	23,904	15,881 (66.4%)	1,696 (7.1%)	925 (3.9%)	672 (2.8%)
1998	27,805	17,756 (63.8%)	1,849 (6.6%)	1,070 (3.8%)	688 (2.5%)

*Underrepresented minorities include African Americans, Hispanics, and American Indians.

Table 2 — Combined Number and Percent of First-year Graduate Student Enrollment in Selected Research I Universities in *Computer Sciences, Engineering, Mathematics, and Natural Sciences* for 1994-95 to 1998-99, N=42

Year	Total Number of Graduate Students	Total US Citizen & Permanent Residents	Underrepresented Minorities*	African Americans	Hispanic Americans
1994	19,486	13,345 (68.5%)	1,290 (6.6%)	691 (3.5%)	544 (2.8%)
1995	19,080	12,711 (66.6%)	1,200 (6.3%)	679 (3.6%)	474 (2.5%)
1996	19,126	12,367 (64.6%)	1,221 (6.4%)	629 (3.3%)	540 (2.8%)
1997	17,518	10,984 (62.7%)	978 (5.6%)	471 (2.7%)	446 (2.6%)
1998	20,033	12,570 (62.7%)	1,138 (5.7%)	578 (2.9%)	505 (2.5%)

*Underrepresented minorities include African Americans, Hispanics, and American Indians.

Table 3 — Percent Changes in First-year Graduate Enrollment in Selected Research I Universities in *Computer Sciences, Engineering, Mathematics, and Natural Sciences,* N =42

	1996	1997	% Change 96 to 97	1998	% Change 97 to 98	% Change 96 to 98
Total	19,126	17,518	- 8.4	20,033	+14.4	+4.7
Total US & Permanent Residents	12,367	10,984	-11.2	12,570	+14.4	+1.6
Underrepresented Minorities*	1,221	978	-19.9	1,138	+16.4	-6.8
African Americans	629	471	-25.1	578	+22.7	-8.1
Hispanic Americans	540	446	-17.4	505	+13.2	-6.5

*Underrepresented minorities include African Americans, American Indians, and Hispanic Americans

Table 4 — Percent Changes in First-year Graduate Student Enrollment in Selected Research I Universities in Computer Sciences, Engineering, Mathematics, and Natural Sciences, Psychology, and Social Sciences, (*All Fields of Science and Engineering*), N =42

	1996	1997	% Change 96 to 97	1998	% Change 97 to 98	% Change 96 to 98
Total	26,631	23,904	-10.2	27,805	+16.3	+ 4.4
Total US & Permanent Residents	18,374	15,881	-13.6	17,756	+11.8	- 3.4
Underrepresented Minorities*	2,125	1,696	-20.2	1,849	+ 9.0	-13.0
African Americans	1,191	925	-22.3	1,070	+15.7	-10.2
Hispanic Americans	836	672	-19.6	688	+ 2.4	-17.7

*Underrepresented minorities include African Americans, American Indians, and Hispanic Americans

Table 5 — Percent Changes for First-year Graduate Student Enrollment in Selected Research I Universities by Fields, *All Students*, N=42

	1996	1997	% Changes 96 to 97	1998	% Changes 97 to 98	% Change 96 to 98
Computer Sciences	1,923	1,707	-11.2	2,051	+20.2	+ 6.7
Engineering	8,572	7,679	-10.4	8,631	+12.4	+ 0.7
Mathematics	1,097	998	- 9.0	1,244	+24.6	+13.4
Natural Sciences	7,534	7,134	- 5.3	8,107	+13.6	+7.6
Psychology	1,612	996	-38.2	1,105	+10.9	-31.5
Social Sciences	5,893	5,390	- 8.5	6,667	+23.7	+13.1

Table 6 — Percent Changes for First-year Graduate Student Enrollment in Selected Research I Universities by Fields, *U.S. Citizens and Permanent Residents*, N=42

	1996	1997	% Changes 96 to 97	1998	% Changes 97 to 98	% Change 96 to 98
Computer Sciences	921	776	-15.7	962	+24.0	+ 4.5
Engineering	5,060	4,384	-13.4	4,547	+ 3.7	-10.1
Mathematics	679	567	-16.5	701	+23.6	+ 3.2
Natural Sciences	5,707	5,257	- 7.9	6,073	+15.5	+ 6.4
Psychology	1,508	903	-40.1	988	+ 9.4	-34.5
Social Sciences	4,499	3,994	-11.2	4,198	+ 5.1	-6.7

Table 7 — Percent Changes for First-year Graduate Student Enrollment in Selected Research I Universities by Fields, *Underrepresented Minorities (African Americans, American Indians, and Hispanic Americans)*, N=42

	1996	1997	% Changes 96 to 97	1998	% Changes 97 to 98	% Change 96 to 98
Computer Sciences	84	49	-41.7	98	+100.0	+16.6
Engineering	480	367	-23.5	375	+2.2	-21.9
Mathematics	56	50	-10.7	74	+48.0	+32.1
Natural Sciences	601	512	-14.8	591	+15.4	- 1.6
Psychology	202	134	-33.7	153	+14.2	-24.2
Social Sciences	702	584	-16.8	628	+ 7.5	-10.5

Table 8 — Percent Changes for First-year Graduate Student Enrollment in Selected Research I Universities by Fields, N=42

African Americans

	1996	1997	% Changes 96 to 97	1998	% Changes 97 to 98	% Changes 96 to 98
Computer Sciences	67	29	-56.7	60	+106.9	-10.4
Engineering	202	152	-24.8	157	+ 3.3	-22.3
Mathematics	31	25	-19.4	31	+24.0	0
Natural Sciences	329	265	-19.5	330	+24.5	0
Psychology	98	80	-18.4	86	+ 7.5	-12.2
Social Sciences	464	374	-19.4	406	+8.6	-12.5

Table 9 — Percent Changes for First-year Graduate Student Enrollment in Selected Research I Universities by Fields, N=42

Hispanic Americans

	1996	1997	% Changes 96 to 97	1998	% Changes 97 to 98	% Changes 96 to 98
Computer Sciences	16	19	+18.8	30	+57.9	+87.5
Engineering	256	193	-24.6	198	+ 2.6	-22.6
Mathematics	22	24	+ 9.1	42	+75.0	+90.9
Natural Sciences	246	210	-14.6	235	+11.9	- 4.5
Psychology	95	50	-47.4	59	+18.0	-37.9
Social Sciences	702	584	-16.8	628	+ 7.5	-10.5

An Interview with Dr. Evelyn Hu

Interviewed by Jolene Jesse, Senior Program Associate

Each issue of Making Strides features a short interview with a science, mathematics or engineering (SME) professor who has been instrumental in mentoring and encouraging students through the pipeline, as well as demonstrating leadership and outstanding accomplishments in the world of SME.

This issue profiles Dr. Evelyn Hu, Professor in the Departments of Electrical and Computer Engineering, and Materials at the University of California, Santa Barbara. Evelyn Hu received her B.A. in physics (summa cum laude) from Barnard College and her M.A. and Ph.D. in physics from Columbia University. From 1975 to 1981, Dr. Hu was a Member of the Technical Staff at Bell Laboratories in Holmdel, NJ. Subsequently, she served from 1981 to 1984 as a Supervisor for VLSI Patterning Processes at Bell Laboratories in Murray Hill, NJ. In 1984, she joined the University of California, Santa Barbara, as a Professor of Electrical and Computer Engineering (ECE). Dr. Hu currently holds joint appointments in ECE and Materials and served as Director of QUEST, an NSF Science and Technology Center. QUEST has now evolved to be iQUEST, an ongoing Institute for Quantum Engineering, Science and Technology, on the UCSB campus. She is also the Scientific Co-Director of the newly formed California Nanosystems Institute, a UCLA-UCSB collaborative California Institute for Science and Innovation. In addition, Dr. Hu is the Director of the UCSB node of the NSF-sponsored national Nanofabrication Users Network. She is also the co-recipient of the AAAS 2000 Mentor Award for Lifetime Achievement for her extraordinary mentoring and for opening the doors for women and other underrepresented students and faculty in electrical and computer engineering.

Dr. Evelyn Hu

MS: ***Tell me about your background and the reasons you chose engineering.***

HU: In a sense, I didn't choose engineering: engineering really chose me. My background is in physics, and all my degrees are in physics. My dissertation advisor was Mme C. S. Wu, a very famous woman physicist who carried out the experiment that confirmed parity nonconservation in weak interactions, and led to the Nobel Prize in Physics for T. D. Lee and C. N. Yang. My thesis experiments required the use of an accelerator at Brookhaven National Laboratories. My graduate experience convinced me that I wanted to be involved in doing science with a greater control over all aspects of the experiments, and perhaps with a more easily discernable relevance to applications and benefits to society. Perhaps this is where engineering ideas first entered my head. When my graduate advisor asked me about what I wanted to do after graduation, I decided that I wanted to make a change in direction and focus. I rather naively remarked on the possibilities of going to work for Bell Laboratories—one of the premier institutions for work on condensed matter physics. It was a naïve remark since I had no background in condensed matter physics, and no real idea then of how prestigious and competitive Bell Labs was. I was lucky enough to be offered a job at Bell Labs, which began a tremendous learning process into other fields of physics and ultimately what can be defined as 'engineering.'

MS: ***Was it difficult making this transition?***

HU: As a fresh Ph.D., even with the experience of carrying out a thesis experiment, I still had everything to learn. While this could be a disadvantage, it was also a tremendous opportunity. I had the chance to learn about and explore new materials, new kinds of devices and new techniques to shape those materials into devices. I benefited tremendously from the initial collaborations and contacts I made at Bell Labs–without their insights and advice, I would never have been able to 'get on board' so quickly.

MS: ***Why did you decide to go back to academia? What were the consequences of your industry experience on your subsequent academic life?***

HU: I had always loved the idea of the university as a place of ideas, where one could learn, interact, and create new things. In a sense, I had always intended to ultimately wind up in a university environment. Even after I started working at Bell, I believe that in the back of my mind, my intention was to some day make the transition to a university career. However, I became fully and happily immersed in my life at Bell Labs. So much so, that nine years later, when I received an offer to come to UCSB to interview for a position, I was taken completely by surprise. One of the surprises was that I was less willing to make the change, less flexible than I wanted to think I was. In fact, the first time I explored the possibility of this university opportunity, I didn't take it. Fortunately, the opportunity came again a few years later, and I was ready to take advantage of the opportunity at that time.

MS: ***I understand you successfully mentored over 40 undergraduate and graduate students from underrepresented groups through degrees in engineering. Did your own experience as a woman in a male-dominated field contribute to your success with students?***

HU: I think our previous experiences always inform how we approach new experiences, situations and people. So there may be some common threads, issues and concerns that link my experiences with those of my students. Being an underrepresented minority or 'a woman in a male-dominated field' suggests greater challenges because of possible differences in familiar 'cultural' contexts, jargon, ways of communicating, skills and approaches to problem solving. This is certainly true, but I believe that for many, if not most students, the transition from undergraduate to graduate school life represents that kind of cultural change.

This is the time when students realize that they have to commit larger and larger proportions of their time to a specialized and focused area of work, which may become a dominant part of their life. They find that they have to sacrifice time and interests to be able to achieve that focus. They experience setbacks in their research; they often doubt their own abilities or determination to make it through–and often feel that they may be the only students that feel the way they do. I think it's important to give them the encouragement that these doubts, setbacks and 'low times' are not unusual, that they can 'make it through.'

I also benefited greatly from having mentors who were my own age. At Bell Labs, we worked, played and went to conferences together. I was new to the field and didn't know the right conferences to go to or journals to publish in. These are important things to know. All graduate advisors need to provide that kind of insight into the field as well as the approaches to research and data gathering.

MS: ***Tell me about iQUEST.***

HU: iQUEST stands for Institute for Quantum Engineering, Science and Technology. Its predecessor, QUEST (Center for Quantized Electronic Structures) was one of the first Science and Technology Centers (STCs) established in 1989 by the National Science Foundation, under the directorship of Professor James Merz. The STCs were proposed as a new way of being able to make advances in research in some of the most challenging areas of science and technology that would require a substantial, 'critical-mass' level of investment in sustained (over 11 years or so) funding, with multi-disciplinary contributions of expertise. There was (and is) a belief that true progress in these challenging areas would best be carried out by breaking across traditional disciplinary boundaries, and examining critical problems with a multifaceted vision. Also integral to the STC program was the firmly grounded belief in the necessity for the integration of education with research, both to educate the students who will be the innovators of the future, and to make the connections and the communication with the community at large.

The first competition for these science and technology centers was in 1987-88. This came at exactly the right time for us at UCSB: we had a critical mass of talents, ideas, and also the already established culture of working together. Our focus on quantized electronic structures–the world and possibilities of very small structures–hit a resonance, and we were fortunate enough to be funded as an STC.

MS: ***Educational initiatives are a large part of iQuest. Was this always the major focus?***

HU: In fact, there was a self-education and self-discovery process that had to take place before most of us realized how important, how exciting, and how much fun it is to be involved in these educational initiatives. We were fortunate to hire on as our education director Dr. Fiona Goodchild, who had strong ties with our Graduate School of Education, strong interests and views on science education, and also had significant ties to the community (the current Education Director for iQUEST is Liu-Yen Kramer). The first program that she established was a program for high school students: Apprentice Researchers at QUEST (ARQ). High school students are paired with graduate student mentors and have the chance to go into the laboratory and have a ‘hands-on’ experience in carrying out research. Their research experience also involves learning to communicate with their peers–to be able to describe their research in succinct, descriptive terms that avoids jargon as much as possible. It is a fantastic experience for both the high school apprentice and the graduate mentor–who both learn a tremendous amount about science, communication, work, fun, and the integration of all these components.

Since then we have built up an extensive portfolio of education programs involving participants at every level—ranging from elementary students to elementary and secondary school teachers. We have summer sessions for students ages 12 to 14 to learn computer and electronic skills. We have a very successful undergraduate internship program. Most recently we have set up a research experience for teachers analogous to our undergraduate research experience, where teachers are assigned graduate student mentors and have their own research project. With the belief that to truly effect change in the perception of and participation in science, you should involve the teachers of science at the elementary, junior high and high school level, we have developed programs to help those teachers network, share insights and information, work with new instrumentation and technology, and interact with researchers at UCSB.

Our programs are all knit and interconnected together, which gives the entire fabric a greater strength and sustainability. Participants from one program may give presentations or participate in other programs. There is a lot of cross-fertilization.

MS: ***Do many of the participants in your iQUEST programs go on to enter SME fields?***

HU: Our tracking shows that an extraordinarily high percentage go into SME fields. Of the first 90 ARQ students, 80% went on to university and registered in science and engineering courses, compared with 35% of students who were tracked in a comparable national study of graduating seniors. About 45 percent of those students are female and about 20 percent are from underrepresented minority groups. We have comparable figures for our undergraduate intern programs. Tracking the ARQ students from the earliest years of our program, 13 out of 23 students who completed their undergraduate degrees went on to graduate study. All but one of those graduate students chose further study in science, engineering or medicine.

MS: ***What skills do you find are most important for the success of students in engineering?***

HU: I think it’s different at each level. For graduate students I look first of all for passion and interest, rather than a student who applies for graduate school but is not exactly sure why. Graduate school involves becoming a specialist, which means a change in lifestyle from one’s undergraduate experience. So I think it is important that a student be willing to get deeply into a research area and continue to be excited about it even when they have been working on it for years and everyone else seems to be doing more interesting work. One needs motivation and passion and the vision to see a project to the end, even more than being ‘smart’ and being able to do the work in the lab. If someone is lukewarm, they may make it through, but they need passion to be the best student.

At the undergraduate level it is easier for students to have a lot of passion and vision and hopes and imagination. Then it becomes important for faculty mentors, and for the university to nourish that vision. At this level there is usually a disparity between vision and passion and your knowledge and skills to realize it. I often see this with entry-level engineering students—they have the vision, but no idea of the skills needed to realize their vision. We don’t help them enough to make those linkages.

MS: ***What is the best way to recruit more women and minorities into SME disciplines?***

HU: Critical mass is important. We have to have a critical mass of women faculty and students in place already to serve as a support network. I believe that retention is a more important issue than recruitment, although the two are related, as the issue is really multifaceted. To recruit people into a field, the area of work must appear to be exciting and rewarding, and achievable—and we don’t do a good enough job at representing that.

Once we recruit students we need to make sure they have the support network necessary to meet their needs and help them deal with the uncertainties and issues they face. In smaller schools, this may not be as critical an issue, but in a school the size of UCSB, with over 18,000 students, it is easy to become anonymous. A student can go here for four years and never carry out a personal discussion with a faculty member. We have a number of student-run organizations that can serve as a ‘home’ or a means of networking for students. But it is essential that students have someone to talk to about where to go to find information or to discuss things with someone who has been through it and can give them reassurances that they can make it through. ■

Thank you so much for your insights, Dr. Hu!

More information about the Institute for Quantum Engineering, Science and Technology (iQUEST) is available at http://www.iquest.ucsb.edu/home/html.

More information about the AAAS Mentor Award for Lifetime Achievement is available at http://www.aaas.org/aaas/award.html.

A Profile of an AGEP Institution: Missouri's Alliance for Graduate Education and the Professoriate (MAGEP)

By Lenell Allen, Senior Project Manager, University of Missouri-Columbia

History and Purpose

The University of Missouri-Columbia is a national leader in providing graduate education opportunities for underrepresented students of color. In 1997, the University received the National Association of Graduate Admissions Professionals Award for Excellence in the Recruitment of Underrepresented Graduate Students. Fellowships, traineeships, research and teaching assistantships, along with a program for waiving educational fees, contributed to the production of more than 100 doctorates in the last decade.

In October 1998, the National Science Foundation extended the University of Missouri-Columbia its first round of Minority Graduate Education (MGE) awards. In 1999, MU's MGE program became known as MAGEP, Missouri's Alliance for Graduate Education and the Professoriate.

The specific objectives of the MAGEP program are to:

- develop and implement innovative models for recruiting, mentoring and retaining students of color in Science, Engineering and Mathematics (SEM) doctoral programs; and
- develop effective strategies for identifying and supporting underrepresented students of color who want to pursue academic careers.

MAGEP is administered through the MU Graduate School with the assistance of an advisory committee consisting of faculty and administrators representing the four University of Missouri campuses (Columbia, Kansas City, Rolla and St. Louis).

MAGEP Programs

MAGEP offers programs for undergraduates, graduate students and current faculty members that will have a long-term impact on institutional, departmental and organizational culture.

Seventeen students took part in MAGEP's 2000 Access to Doctoral Education Summer Research Program. ***(seated, left to right)*** *Adrian Jacobs; Rosalie Connor; Tamika Tyson; Sharline Bryan; Adrienne Floyd.* ***(2nd row)*** *Charles Sampson, Co-Principal Investigator; Andre Logan; Rocio Mendez; Kimberly Bardell; Harvey Cline; Alleda Flagg; Jacqueline Ivey; Lenell Allen, Project Manager; Danielle Brown; Awilda Blanco; Cynamon Graves; Latrica Williams.* ***(3rd row)*** *Olga Bolden-Tiller, Graduate Assistant; Negussie Tesfeledet; Richard Clemon; and Jerome Anderson, Graduate Assistant.*

MAGEP Fellows Program

MAGEP offers five-year fellowships to underrepresented graduate students of color in doctoral degree programs. The purpose of the program is to recruit and train the students as future faculty members in the SEM fields. In addition to receiving financial support and training, MAGEP Fellows meet with their mentors regularly, present their research at conferences around the country, and submit their work to journals in their field. A selective list of conferences and journals that have featured MAGEP Fellow research include, among others: *The Journal of the American Veterinary Medical Association; Midwest Developmental Biology Meeting; Midwest Crystallography Meeting; Geological Society of America National Meeting; Permo-Carboniferous Carbonate Reefs Conference; Conference on Cryptography and Number Theory*. Fellows have completed an average of 60 hours toward the doctoral degree with a average GPA of 3.6. Five fellows have currently successfully completed their comprehensive examinations.

Access to Doctoral Education

The Access to Doctoral Education Program introduces promising juniors and seniors majoring in SEM fields to career opportunities in academia through an eight-week mentored research experience. The program also includes GRE preparation, workshops and seminars on graduate school education, and an opportunity to present their research at the end of the summer.

During the 2000 inaugural summer, 17 students participated from 13 different schools including Stanford University, University of the Virgin Islands, Princeton University, Spelman College, Xavier University, North Carolina State University and Polytechnic University of Puerto Rico.

continued on next page

Multicultural Teaching Scholars Program

In the Multicultural Teaching Scholars Program, individuals from underrepresented groups who have completed or are near the completion of a doctoral degree are provided the opportunity to teach a summer course at the University of Missouri-Columbia. The program enhances the ability of MU departments to recruit members of underrepresented groups for future employment and introduces MU students to faculty more representative of America.

Other Partnerships

MAGEP has established new partnerships, including supporting linkages with Florida A&M University and Sandia National Laboratories. Facets of these partnerships include faculty and student exchange and training, internship opportunities and shared research. Distance education and Internet courses, discussion of undergraduate recruitment, retention and curriculum issues, computer and laboratory development take place among the participating institutions.

The engineering department at the University of Missouri-Columbia is closely tied with Polytechnic University of Puerto Rico's (PUPR) civil engineering program through the MU/PUPR Doctoral Studies in Engineering Program. In the alliance, MU faculty train PUPR faculty members and students toward the doctoral degree. A strong Hispanic and Latin American graduate program is under construction within the department at MU as well. Dr. Erik Loehr, Dr. John Bowders, Dr. Kristen Sanford-Berhardt and Dr. Mark Virkler are researching topics and education outreaches directly applicable to the Caribbean, Latin and South American regions. Through their combined efforts under the direction of Dr. Sam Kiger, department chair, the department's student population has significantly increased within the last three years.

PUPR Students:

Jose Rodriguez, Mechanical and Aerospace Engineering; **Dharma Delgado,** Nuclear Engineering; **Othoniel Rodriguez-Jimenez,** Computer Science and Engineering; **Vanessa Amado Gonzalez,** Civil Engineering; **Omaira Collazos,** Civil Engineering

MAGEP Fellows:

1998-1999
Stephanie Bingham, Biological Sciences; **Eliodora Chamberlain,** Fisheries/ Wildlife; **Larry Ellis,** Mathematics; **Terence Farmer,** Mathematics; **Aaron Johnson,** Geological Sciences; **Emmett Lodree,** Jr., Industrial & Manufacturing Engineering; **Ronald Tessman,** Veterinary Pathobiology; **Christina Wilson Hughes,** Horticulture

1999-2000
Wendell French, Molecular Microbiology & Immunology; **Jermaine Jenkins,** Biochemistry; **Jose Rodriguez,** Mechanical Engineering.; **Dusty Weaver Nagy**, Veterinary Pathobiology; **Shelonda Finch,** Chemistry; **Tito Pope,** Engineering Management

2000-2001
Ondrea Bermudez, Chemical Engineering; **George Green,** Mathematics; **Tamela Green,** Mathematics; **Anthony Iyoho,** Mechanical Engineering; **Daniel Lee,** Biology; **Jorge Parra,** Civil Engineering

Alliance Members

Dr. Brady Deaton
Principal Investigator
Provost
University of Missouri-Columbia

Dr. Charles Sampson
Co-Principal Investigator
Vice Provost/Project Director
University of Missouri-Columbia

Lenell Allen
Senior Project Manager
University of Missouri-Columbia

Bev Vaughn
Administrative Assistant
University of Missouri-Columbia

Dr. Patricia Hovis
Site Coordinator
University of Missouri-Kansas City

Constance Mahone
Assistant Site Coordinator
University of Missouri-Kansas City

Dr. Harvest Collier
Site Coordinator
University of Missouri-Rolla

Floyd Harris
Assistant Site Coordinator
University of Missouri-Rolla

Dr. Patricia Barton
Site Coordinator
University of Missouri-St. Louis

Dr. Godfrey Bourne
Assistant Site Coordinator
University of Missouri-St. Louis

For further information consult the MAGEP Web site at: *http://www.missouri.edu/~gradschl/magep/*

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Managing Editor: Yolanda S. George
Editor: Jolene Jesse
Art Director: Ann M. Williams

American Association for Advancement of Science
1200 New York Avenue, NW
Washington, DC 20005
202-326-6631
e-mail: mge@aaas.org
http://ehrweb.aaas.org/mge/

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