Status of Underrepresented Minorities in Science, Technology, Engineering, and Mathematics (STEM)

OVERVIEW

- Presentation Abstract
- Black History Month
- Political and Social Factors
- The role of colleges and universities and governmental agencies at the Federal, State, and Local level in increasing the number of underrepresented minorities
- Finding effective and systemic strategies which improve the racial climate and promote understanding and sensitivity on the various campuses
- Finding effective and systemic strategies which improve the recruitment and retention of underrepresented minorities

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PRESENTATION ABSTRACT

One of the most frequently discussed topics in academic and governmental circles today is what should be the role of colleges and universities and governmental agencies at the Federal, State, and Local level in increasing the number of underrepresented minorities in the professional ranks of mainstream America, finding effective and systemic strategies which improve the racial climate and promote understanding and sensitivity on the various campuses, and improving recruitment and retention of minorities.

This discussion—especially for STEM fields—is extant at the undergraduate as well as the graduate level. We suggest solutions which partially address this chronic and acute problem of identifying, attracting, motivating, retaining, and then preparing talented underrepresented minority undergraduate students for graduation with STEM baccalaureate degrees, for further STEM graduate studies—especially at the doctorate level, and for productive careers in science, technology, engineering, and mathematics.

BLACK HISTORY MONTH

Successor to Negro History Week (Carter G. Woodson)

POLITICAL AND SOCIAL FACTORS

Affirmative Action and Equal Employment Opportunity

Reverse Discrimination

The Supreme Court

The Problem

- The chronic and acute problem of identifying, attracting, motivating, retaining, and then preparing talented underrepresented minority undergraduate students for graduation with STEM baccalaureate degrees, for further STEM graduate studies—especially at the doctorate level, and for productive careers in science, technology, engineering, and mathematics.

- The level of participation of minorities in STEM in the United States is extremely low.
  - Indeed, minorities (Black, Hispanic, and Native American) are very much underrepresented in STEM with respect to their percentage of the total United States Population.

- The minority population as a percentage of total United States population is expected to continue to grow at a rapid pace for the foreseeable future.

Specifically, suggested solution components should be as comprehensive, multi-disciplinary, and as collaborative as possible. The mission goals of a really good solution should include the capability:

- To increase significantly the number and quality of underrepresented minority students receiving STEM baccalaureate degrees;
- To increase the size of the pool of interested and academically qualified underrepresented minorities eligible for STEM graduate study; and
- To increase the number of underrepresented minority students entering graduate schools who ultimately attain the doctorate in STEM fields.

Some Historical Background

The serious and disturbing nature of the gross underrepresentation of minorities in science

Upon reviewing data from 1972-2006, the U.S. Department of Education, National Center for Education Statistics (NCES) found that although the college enrollment participation rate has improved for both Whites and African-Americans, the gap between the two groups has fluctuated resulting in no essential change over that period.

In 2006, the gap was 13% [69% (White) versus 55% (Black)]. For Hispanics, a similar situation obtains with a gap of 13% [69% (White) versus 58% (Hispanics)]. *Income is a factor in the above-mentioned data*: The college enrollment rate was higher for high-income family students and lower for those students whose parents had less education or were low-income *Students whose parents had less education* also had lower rates of college enrollment in the period 1992–2006 when compared with students whose parents had a bachelor's degree or higher.

Some Historical Background

The serious and disturbing nature of the gross underrepresentation of minorities in science

- In 2007, African-Americans comprised roughly 4 percent of all employed doctorate scientists and engineers in this country even though they were about 12 percent of the general population.

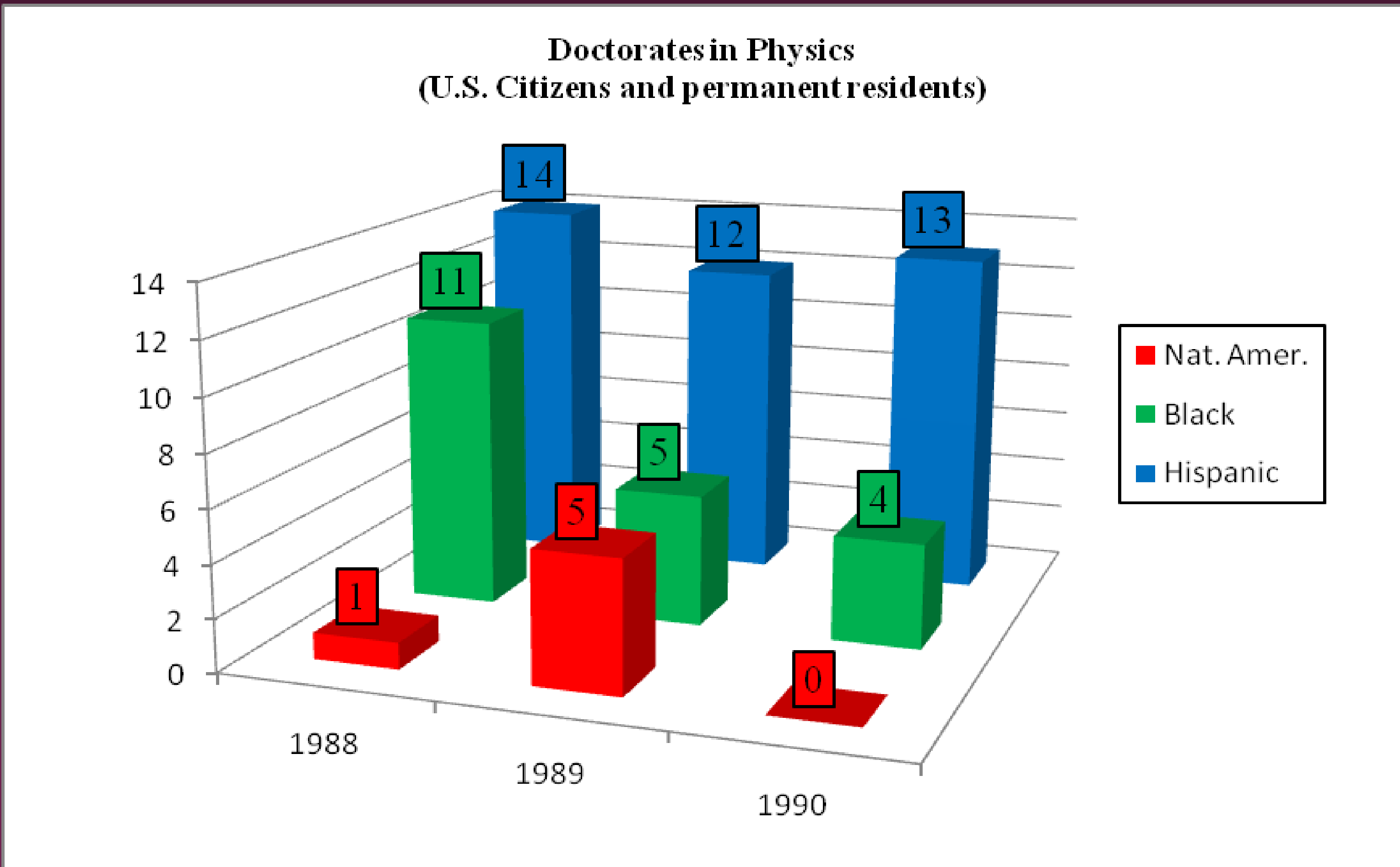
- Hispanics comprised roughly 3% of all employed doctorate scientists and engineers in this country but constituted about 15 percent of the general population.

- In 1988 only 47 African-Americans earned science Ph.D.s and only 15 in engineering. While a few more Hispanics went into hard science fields, their numbers were quite small.

- In 1980, about 9.5% of high school seniors 19 years of age and older were Hispanic, whereas 8% were Black. The national average at the time was only 4%.

- In 1980, Hispanics earned 69 doctorates in the physical sciences and 43 in engineering, or only 2.3% of all doctorates awarded to U.S. citizens in those areas, whereas American Indians earned 0.3% (11 doctorates in the physical sciences and 4 in engineering) of all doctorates awarded to U.S. citizens.

Black, Hispanic, and Native American Doctoral Recipients in Physics (1988-1990)



DOCTORATES IN PHYSICS (U. S. CITIZENS AND PERMANENT RESIDENTS) BY RACE/ETHNICITY AND DISCIPLINE (1988-2006)

Gross Underrepresentation of Minorities in Physics

Discipline	Year	Black	Hispanic	Nat. Amer.	Asian	Other	White	Total
Physics	1988	11	14	1	19	32	646	723
	1989	5	12	5	33	21	599	675
	1990	4	13	0	32	25	645	719
	1997	14	22	2	157	29	659	883
	1998	10	18	1	111	32	652	824
	1999	8	16	3	66	19	630	742
	2000	16	23	1	68	13	571	692
	2001	16	15	0	68	25	558	678
	2002	22	21	2	60	23	461	589
	2003	17	24	0	64	25	430	555
	2004	11	13	1	44	35	453	559
	2005	13	16	2	65	28	444	567
	2006	11	12	1	49	18	511	604

DOCTORATES IN SELECTED STEM FIELDS

(U. S. CITIZENS AND PERMANENT RESIDENTS)
BY
RACE/ETHNICITY AND DISCIPLINE (1988-1990)

<u>Gross</u> Underrepresentation of Minorities

Discipline	Year	Black	Hispanic	Nat. Amer.	Asian	Other	White	Total
Chemistry	1988	17	43	5	48	29	1235	1377
	1989	20	40	5	42	24	1167	1276
	1990	12	48	3	53	24	1218	1358
Computer Science	1988	1	2	0	18	6	217	244
	1989	0	3	2	14	15	240	274
	1990	1	3	0	9	8	269	290
Engineering	1988	19	43	4	141	44	1530	1781
	1989	24	34	7	173	43	1583	1864
	1990	28	39	4	152	35	1669	1927
Mathematics	1988	2	3	2	17	10	308	342
	1989	6	8	0	13	15	351	393
	1990	4	7	1	9	7	341	369
Physics	1988	11	14	1	19	32	646	723
	1989	5	12	5	33	21	599	675
	1990	4	13	0	32	25	645	719

DOCTORATES IN SELECTED STEM FIELDS

(U. S. CITIZENS AND PERMANENT RESIDENTS)

BY

RACE/ETHNICITY AND DISCIPLINE (2001-2004)

Gross Underrepresentation of Minorities

Discipline	Year	Black	Hispanic	Nat. Amer.	Asian	Other	White	Total
Chemistry	2001	56	59	5	138	97	1,028	1,383
	2002	46	48	7	120	103	1,031	1,355
	2003	47	44	6	111	88	1,078	1,374
	2004	51	58	9	127	90	986	1,321
Computer Science	2001	9	12	1	53	33	287	395
	2002	21	19	1	72	33	264	410
	2003	17	11	1	55	47	282	413
	2004	18	18	1	62	47	309	455
Engineering	2001	98	88	10	398	124	1844	2562
	2002	80	88	6	357	138	1592	2261
	2003	94	106	12	292	162	1571	2237
	2004	99	101	8	346	160	1633	2347
Mathematics	2001	17	17	2	55	34	400	525
	2002	14	9	1	26	28	360	438
	2003	19	17	1	43	44	389	513
	2004	8	23	0	48	41	388	508
Physics	2001	16	18	0	73	54	516	677
	2002	22	19	2	45	43	473	604
	2003	17	19	0	53	65	437	591
	2004	11	13	3	37	56	442	562

DOCTORATES IN SELECTED STEM FIELDS

(U. S. CITIZENS AND PERMANENT RESIDENTS)
BY
RACE/ETHNICITY AND DISCIPLINE (2005-2009)

Gross Underrepresentation of Minorities

Discipline	Year	Black	Hispanic	Nat. Amer.	Asian	Other	White	Total
Chemistry	2005	37	57	6	139	106	1,021	1,366
	2006	43	70	6	160	102	1,080	1,461
	2007	64	65	3	155	106	1,071	1,464
	2008	62	89	4	150	116	993	1,414
	2009	66	86	7	148	134	1,145	1,586
Computer Science	2005	19	17	0	88	68	308	500
	2006	21	6	6	92	70	356	551
	2007	30	17	3	111	82	437	680
	2008	24	16	0	87	94	446	667
	2009	30	23	2	116	76	483	730
Engineering	2005	101	98	6	372	179	1696	2452
	2006	110	105	7	470	204	1818	2714
	2007	117	138	8	508	250	1973	2994
	2008	128	130	15	501	294	2112	3180
	2009	139	153	19	504	324	2235	3374
Mathematics	2005	18	21	0	54	49	398	540
	2006	20	27	0	63	45	428	583
	2007	21	21	1	79	65	458	645
	2008	22	29	2	53	75	490	671
	2009	27	35	3	78	86	559	788
Physics	2005	15	16	1	62	56	435	585
	2006	11	21	3	54	50	496	635
	2007	20	22	4	60	71	519	696
	2008	15	20	1	57	79	582	754
	2009	11	25	3	53	86	603	781

Symmetry Magazine Excerpt

(DOE Fermilab/SLAC Publication), Vol. 6, Issue 6, July 9, 2009)

- Women and members of underrepresented minorities have gained ground in scientific fields.
- From 1966 through 2006, the percentage of PhDs earned by women in all science and engineering fields increased from 8 percent to 38 percent. But while women were earning 34 percent of all chemistry PhDs by 2006, they were awarded only 17 percent of physics PhDs that year, according to the National Science Foundation.
- As for minorities, their numbers are still so low that Roman Czujko, director of the statistical research center at the American Institute of Physics, does not like to state them in percentages. "To tell you the truth, when I produce reports that say that the numbers have grown by 0.4 percent, people read right past it," he says. "That's the kind of thing we're talking about here." But when people learn that of the 41,446 PhDs granted in physics from 1973-2005, only 303 went to blacks, 504 to Hispanics and 43 to Native Americans, "it has a startle effect," Czujko says.
- In addition, large percentages of physics students and researchers in the United States are foreign. American citizens earned 75 percent of physics PhDs in 1973, but only 40 percent in 2006, according to the National Science Foundation.
- As opportunities in their home countries increase, an increasing number of foreign scientists are expected to go back, and not enough Americans are being attracted into the workforce to replace them.
- With the United States on track to become a majority-minority nation by 2042, it needs to attract more American women and minorities into science to ensure a robust scientific workforce in the future and boost the country's competitiveness, security, and defense, says Ernestine Psalmas, senior program officer for the National Academy of Sciences.
- As Bill Valdez, director of the US Department of Energy's Office of Workforce Development for Scientists and Teachers, puts it, "We have a stewardship responsibility to ensure that the next generation of physicists exists out there."

Seminal Solution Components

- Ion beam and accelerator physics theory and applications, materials science and condensed matter physics, chemistry, plasma and fluid dynamics science, environmental science theory and applications, quantum and nuclear physics theory and applications, computational science, mathematical modeling theory and applications, computer sciences, nanoscience theory and applications and associated nanotechnology, medical physics, and engineering associated with the afore-mentioned topics.
- ***Critical*** The *creation and administration of an effective program* designed to identify, attract, motivate, retain, and prepare talented minority undergraduate students engaged in the topical components mentioned above for graduation with STEM baccalaureate and graduate degrees.

Seminal Solution Components
(continued)

- ***Critical*** The lack of sufficient numbers of underrepresented minorities in science, technology, engineering, and mathematics fields is a problem of serious national concern and a solution must entertain the development and implementation of an *alliance* or *consortium* arrangement with universities, national laboratories, foundations, governmental units, and industry. A solution plan must also provide early research experience to participating students, strengthen the academic environment at all participating universities; provide mentoring, counseling, and role models for participants; and further promote the partnerships among alliance or consortium partners.
- ***Critical*** Many informative, non-partisan governmental and professional society websites exist from which one can draw the following conclusion: Universities which have the most success in recruiting, retention, and graduation of minorities generally have programs and resources of a systemic nature and which have a critical mass of motivated personnel.

Program Solution Outline

Sample Program at an University Organizational Unit (UOU)

Primary Goal of the UOU Program (UOUP) is to Increase Significantly the Number of Undergraduate and Graduate Degrees in STEM Earned by Underrepresented Minorities.

Question: How to Achieve Effectively and Efficiently UOUP Mission Success?

Expect that proper implementation of the UOUP outlined below to increase the minority pool of STEM doctoral candidates of a typical UOU by approximately 20% on a nation-wide basis and within a time frame of five to six years or less

Program Solution Outline

Sample Program at an University Organizational Unit (UOU)

(continued)

UOUP (Phase One–Freshmen and Sophomores)

- Systemic Recruitment of Targeted Minorities
- Systemic Retention of Targeted Minorities
- Systemic Use of STEM Gateway Courses for Targeted Minorities
  - » Vector Analysis course under the in-place curriculum or the creation of a special topic course. Understanding and utilization of vectors is (generally) a major obstacle for STEM-UOUP participants.
  - » Summer course(s) in STEM subject(s)—Interdisciplinary preferred
  - » Summer "Hands-on" laboratory course involving student presentations.
  - » Integration and coordination and interfacing with ongoing UOU educational projects.
- Systemic Recruitment of Minorities Who Require Additional Help (academic or financial)
- Provide Access to Visiting Minority Lectureship (VML) Scientists or Engineers or Mathematicians
  - » Two or three day visit by a VML Scientist or Engineer or Mathematician who would give a STEM colloquium and meet with UOUP students and interested faculty.

Program Solution Outline

Sample Program at an University Organizational Unit (UOU)

(continued)

UOUP (Phase Two–Juniors and Seniors)

- Primary Research Experience UOUP Phase—Juniors and Seniors
- Systemic Use of STEM Gateway Courses
  - » Vector Analysis (including differential and integral calculus and an introduction to tensors) course under the in-place curriculum or the creation of special topic courses. Understanding and utilization of vectors at this level—stress and strain, deformations, heat transfer, electric and magnetic fields, *etc.*—is (generally) a major obstacle for potential STEM-UOUP participants. Success in this area almost guarantees UOUP mission success at the undergraduate level.
  - » Summer course(s) in STEM subject(s)—Interdisciplinary and "job market aware" preferred.
- Summer Research Internship Placement along with Gateway Course Usage
- Promote Systemic Change in Curriculum to Create Credit Courses Suitable (general degree credit is acceptable) for UOUP Undergraduate Researchers
- Provide Access to Visiting Minority Lectureship (VML) Scientists or Engineers or Mathematicians
  - » Two or three day UOU visit by a VML Scientist or Engineer or Mathematician who would present a STEM colloquium, meet with UOUP students and interested faculty, and provide additional services conductive to UOUP mission success.

Program Solution Outline

Sample Program at an University Organizational Unit (UOU)

(continued)

UOUP (Phase Three–Graduate Students)

- Create an *Undergraduate to Graduate Bridge Phase* of the UOUP. Supply a program of support which will successfully orient students to the demands of graduate level education by providing an academic environment favorable and conducive to the successful transition from undergraduate to graduate study
  - » This will require close coordination with Colleges, Departments and Schools, and Centers.
  - » Provide STEM RA and TA partial or full assistance as appropriate.
  - » Enrich the undergraduate educational training of participants by involving them in undergraduate research and teaching as an integral part of the program.
- Provide Guidance and Advice to UOUP Graduate Students
  - » Involve STEM postdoctoral fellows
    - – This will require close coordination with Colleges, Departments and Schools, and Centers already involved in STEM research at the graduate level.
- Provide Access to Visiting Minority Lectureship (VML) Scientists or Engineers or Mathematicians
  - » Two or three day UOU visit by a VML Scientist or Engineer or Mathematician who would give a STEM colloquium and meet with UOUP students and interested faculty.

In Order to Effectively Administer the UOUP, It is Very Important to Note the Following:

- The Admissions, Bursar, and Financial Aid offices, the Research Office, STEM-related Dean's Offices, and other administrative offices must function in a very synergistic fashion. Stipends or other aid to UOUP participants should not result in replacement of already extant participant resources—quite often such stipulations can be negotiated—a situation which can cause severe financial problems (example: a reduction in an existing student loan corresponding to the UOUP stipend received) for participants. UOUP faculty participants should receive recognition of their involvement at all administrative levels including the departmental and college/school/center level. Such recognition may well require some release time. Existing external funding or new funding sources can often be tailored to supplement in a true fashion UOUP activities.

Pertinent Statistical Data

- Average Student Debt for the College Class of 2010: $25, 250;
- Enrollment Decrease Among Families Experiencing Home Equity Decline: 30%;
- Student Loans in Default is 8.8% and Number of Recent College Graduates Who Can't Pay Their Loans is 317,000.
- Median Before-Tax Earnings: High School Graduate $33,800, Some College but no Degree $39,700, Bachelor's Degree $55,700, Master's Degree $67,300, Doctoral Degree $91,900, Professional Degree $100,000.

In Order to Effectively Administer the UOUP, It is Very Important to Note the Following:

(continued)

- There are numerous foundations and agencies which have keen interest in projects that contain strong mission goals in medical research and the application and dissemination of such research at the national and international level. The same situation obtains for work in computational science, materials science, nanotechnology, and nanoscience. These entities could provide funding which would help ensure the long-term sustainability of the UOUP and could aid in the development of a fully functional interdisciplinary UOU “Tech Park”.

- Thus, the UOUP should focus on submission of proposals which tend to emphasize research (for example) on: dielectric wall accelerators (DWA) for use in compact proton therapy and ion beam accelerators (Pelletron) which offer a broad range of nuclear applications in environmental management (ocean engineering, geophysics, *etc.*), cultural heritage (non-destructive dating analysis, anthropological analyses, *etc.*), natural resources, human health (oncological, ophthalmic, epidemiological, *etc.*), and industry.

- Ion beam accelerators are also well suited to handle manpower development opportunities in areas such as radiation detection, nuclear instrumentation, high voltage, and vacuum systems; and developing a knowledge base from which UOU faculty could participate more fully in activities at advanced nuclear facilities such as high flux research reactors, synchrotron light sources, spallation neutron sources, and specialized ion beam facilities. A facility at an UOU built around such an accelerator should also be designed to facilitate undergraduate and graduate teaching and research and to serve as a showcase for prospective students (and their parents) and alumni and consortium partners. In most cases, there exist a number of faculty at a typical UOU—Medical School, College of Engineering, College of Arts and Sciences—for whom such an instrument would be invaluable for their basic and applied research and research with technology transfer and collaborative possibilities. At present, there are only a small number of such facilities in the USA.

Selected STEM Charts and Data and Links

We present a few 6-year graduation rate charts and corresponding data (unless otherwise noted, most source data is derived from the Department of Education with corresponding charts prepared by Prof. M. D. Slaughter).

We also present some links to interesting and informative websites that contain STEM data on underrepresented. The web sites at http://www.collegeresults.org (interactive search engine), http://www.edtrust.org, http://www.jbhe.com, and http://www.americanprogress.org/ are especially useful. Much of the data presented in this document are derived directly from the National Center for Education Statistics of the Department of Education.

Conclusion and Recommendations

Conclusion

As easily ascertained, significant progress over more than two decades for underrepresented minorities has not been achieved in STEM education.

Recommendations

- Formation of a Consortium composed of representatives from appropriate government agencies , academe, industry, federal R&D national laboratories, and professional scientific societies charged with the sole mission of ensuring the short-term and long-term health of STEM education from K-12 through graduate school.

- I envision the Department of Education and the National Science Foundation as having the lead responsibility (oversight) in such a Consortium. Such a consortium—must of course carry out its responsibilities in such a fashion as to ensure dynamic balance between its research and education missions.

Conclusion and Recommendations

(continued)

- *The Consortium must always represent the true cross-sectional views of the full spectrum of government agencies, academe, industry, federal R&D national laboratories, and professional scientific societies of which it consists. Some checks and balances would have to be instituted in order to protect and promote the interests of smaller less influential schools or other affected organizations.*
- The Consortium must have the authority to recommend long-term (*i.e.* substantially longer than the usual grant periods of 1-3 years) projects for funding and ultimately—depending upon evaluation results—for institutionalization.