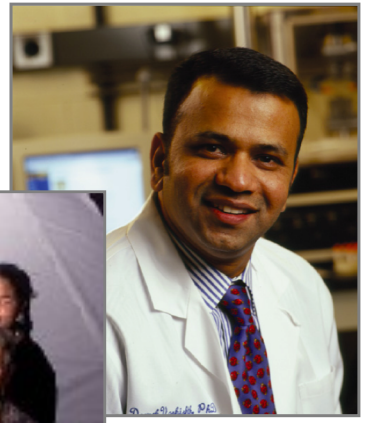


# Women in Engineering in the Year 2020: Possible, Probable and Preferable Scenarios

*Alice M. Agogino*







# NAE Engineer of 2020

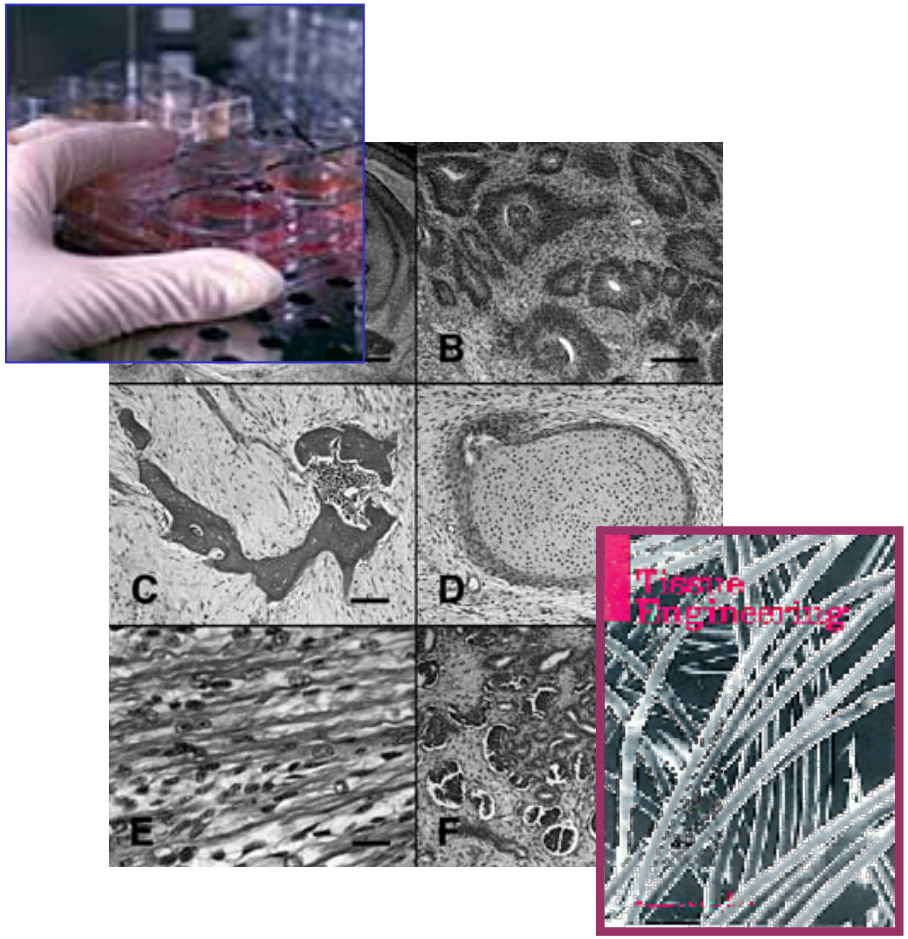
- Phase I – The Engineer of 2020: Visions of Engineering in the New Century


- Phase II – Educating the Engineer of 2020: Adapting Engineering Education to the New Century

# Technology Drivers

- Growing complexity, uncertainty, and interdisciplinary foundations of engineered systems
- The diminishing half-life of engineering knowledge in many fields
- The accelerating pace of technological advance:
  - Bioengineering, biotechnology & biomedical technology
  - Miniaturization (MEMS, nanotechnology, advanced materials)
  - Information Technology
  - Complex and large-scale systems integration

# Bioengineering, Biotechnology & Biomedical Technology



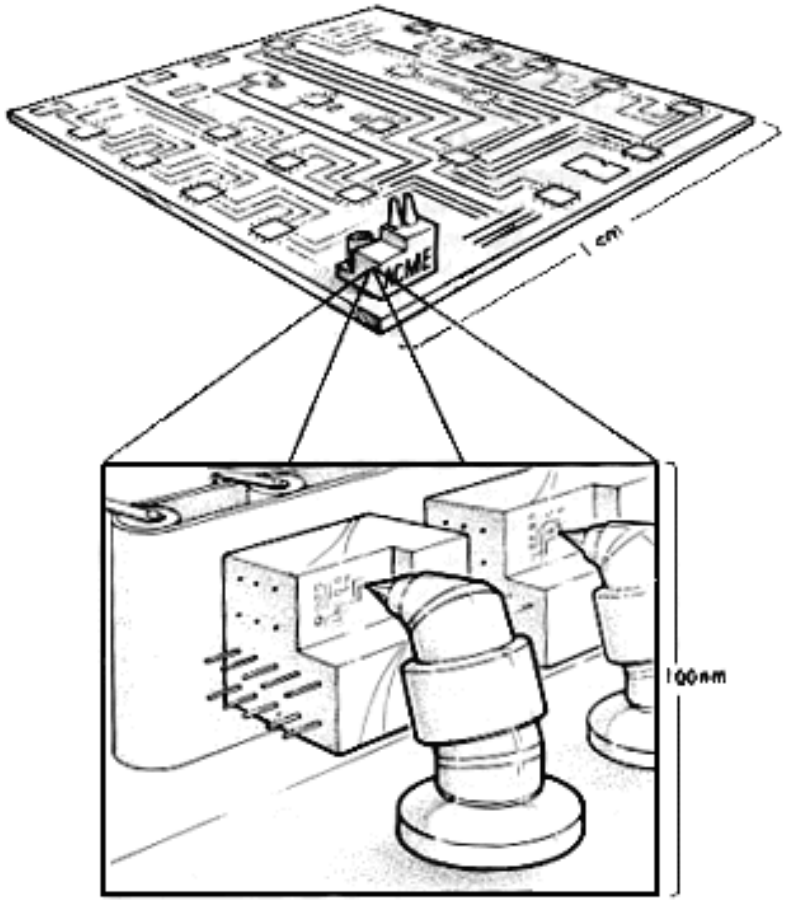

- Advances in biotech have already significantly improved the quality of our lives
- More dramatic breakthroughs ahead
- Tissue engineering
- Regenerative medicine
- Drug delivery engineering
- Bio-inspired computing
- Protection from biological terrorism

# Grand Challenges in the National Nanotechnology Initiative

| Time Frame | Strategic Challenges |
|---|---|
| Nano-Now | • Pigments in paints<br>• Cutting tools and war resistant coatings<br>• Phamaceuticals and drugs<br>• Nanoscale particles and thin films in electronic devices<br>• Jewelry, optimal and semiconductor wafer polishing |
| Nano-2007 | • Biosensors, transducers and detectors<br>• Functional designer fluids, propellants, nozzles and valves<br>• Flame retardant additives<br>• Drug delivery, biomagnetic separation, and wound healing |
| Nano-2012 | Nano-optical/electronics & power sources<br>High-end flexible displays<br>NEMS-based devices<br>Faster switches and ulta-sensitive sensors |

# Nanostructures have been proposed as:

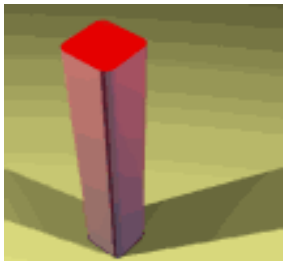
- Environmental cleaning agents
- Chemical detection agents
- Creation of biological (or artificial) organs
- Ultra-fast, ultra-dense, circuits
- A factory large enough to make over 10 million nanocomputers per day might fit on the edge one of today's integrated circuits.

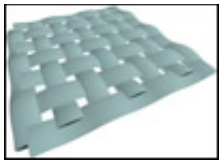



*Assembler with factory on a chip* - Drexler and Peterson

# Materials Science & Photonics

- Smart materials and structures, which have the capability of sensing, remembering & responding (e.g., to displacements caused by earthquakes and explosions; smart textiles provide cooling and heating).
- "As the physical sizes of optical sources decrease, while their power and reliability continue to increase, photonics based technologies will become more significant in engineered products and systems." Applications: fiber optics, precision cutting, visioning and sensing; photochromic windows.

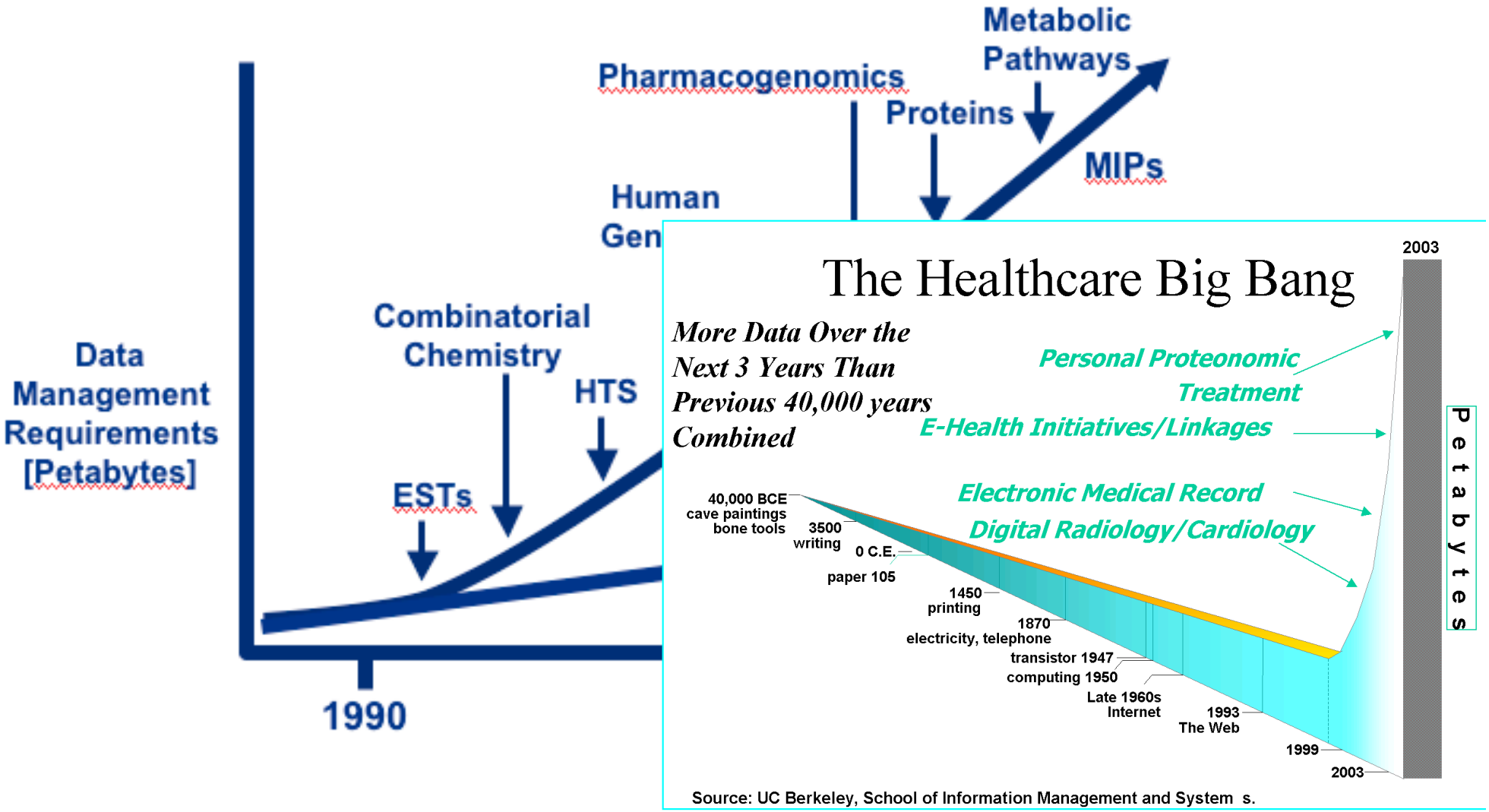




# Information and Communication Technology

- “Today a 1 gigabit hard drive ships in a package 11 x 11 x 1/8 inches; soon that will be a 10 gigabit drive and computers small enough to fit into trouser pockets will be able to contain information that would fill a modern library (Feldman, 2001)”
- “The speed and computing power in future desktop machines and software will enable design and simulation capabilities that will make them routine activities of contemporary engineers obsolete, thus freeing them for more creative tasks.”

# Example of Information Explosion in Healthcare



# Socio-Technological Challenges

- Physical infrastructures in urban settings
- Information and communications infrastructures
- Technology for an aging population
- The environment & sustainable engineering
- Managing complex interdisciplinary problems
- Managing globalization
- Consumers will demand more and more: higher quality, mass customization, personalization, etc.
- Socio-political tensions around the world
- Growing diversity of the workforce

# The Changing Roles of Engineers

- Globalization of industry and engineering practice
- The shift of engineering employment from large companies to small and medium-sized companies, and the growing emphasis on entrepreneurialism
- The growing share of engineering employment in non-traditional, less-technical engineering work (e.g., management, finance, marketing, policy)
- The shift to a knowledge-based “services” economy
- Increasing opportunity for using technology in the education and work of the engineer

# Successful Attributes for the Engineer of 2020

- Possess strong analytical skills
- Exhibit practical ingenuity; posses creativity
- Good communication skills with multiple stakeholders
- Business and management skills; Leadership abilities
- High ethical standards and a strong sense of professionalism
- Dynamic/agile/resilient/flexible
- Lifelong learners
- Ability to frame problems, putting them in a socio-technical and operational context

# Results from a Survey of NAE Frontiers of Engineering Alumni

- Frontiers of Engineering participants
  - Carefully selected as future leaders in engineering
  - Mostly young – 30 to 45, (will be active in 2020)
  - 61 respondents from academia, 44 from industry
  - Respondents on average have worked in field (industry/academia) for over 10 years
  - Involved in cutting edge engineering topics
- Intent was not to make recommendations on curricula – but to assess how well their education had prepared them for the issues they will face in engineering practice out to 2020

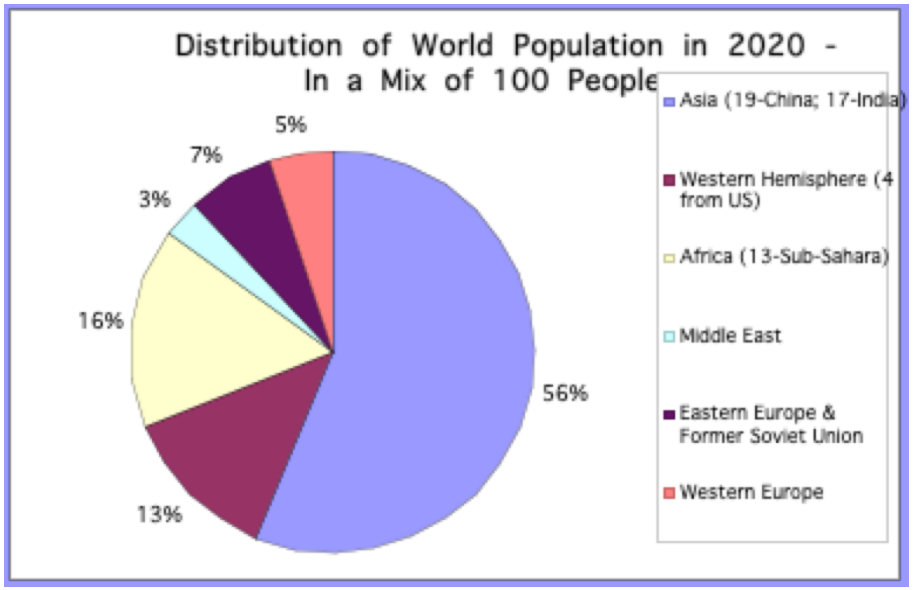
# Problems Engineers Will be Solving in 2020

- Environmental and energy related problems
- Bioengineering problems (including medical)
- Ultra-nanoscale, miniaturization
- Problems related to population growth
- Managing globalization
- Maintaining technical currency & life long learning

# The Environment

- Three quarters of the US population resides in areas with unhealthy air. [American Lung Association]
- In 2020, California will need 40% more electrical capacity, 40% more gasoline, and 20% more natural gas than in 2000.
- 50% of the world's original forest cover has been depleted [Worldwatch Institute] and global per capita forest area is projected to fall to 1/3 its 1990 value by 2020. [Haque, 2000].
- 48 countries (2.8 billion people) face freshwater shortages in 2025 [Henrichsen, 1997]
- The wealthiest 16% of the world consumes 80% of the world's natural resources. By the year 2020, there will be 8 billion people who will further depleting the environment and fuel political instability if the inequity of these resources continues. [CIA 2001].

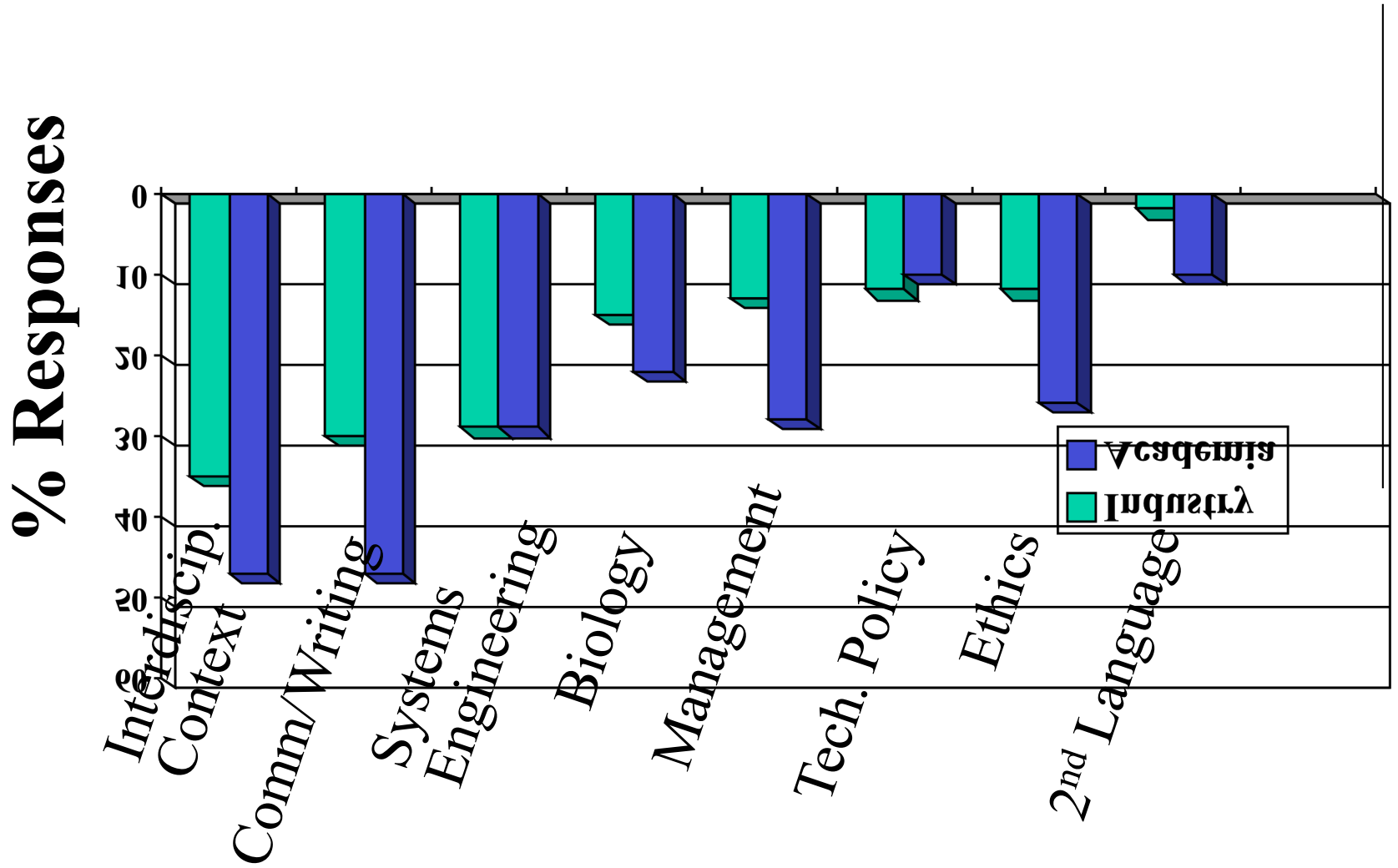
# The World Population (CIA, 2001)




- In contrast to the aging of the US, Europe and Japan, the most politically instable parts of the world will experience a "youth bulge".

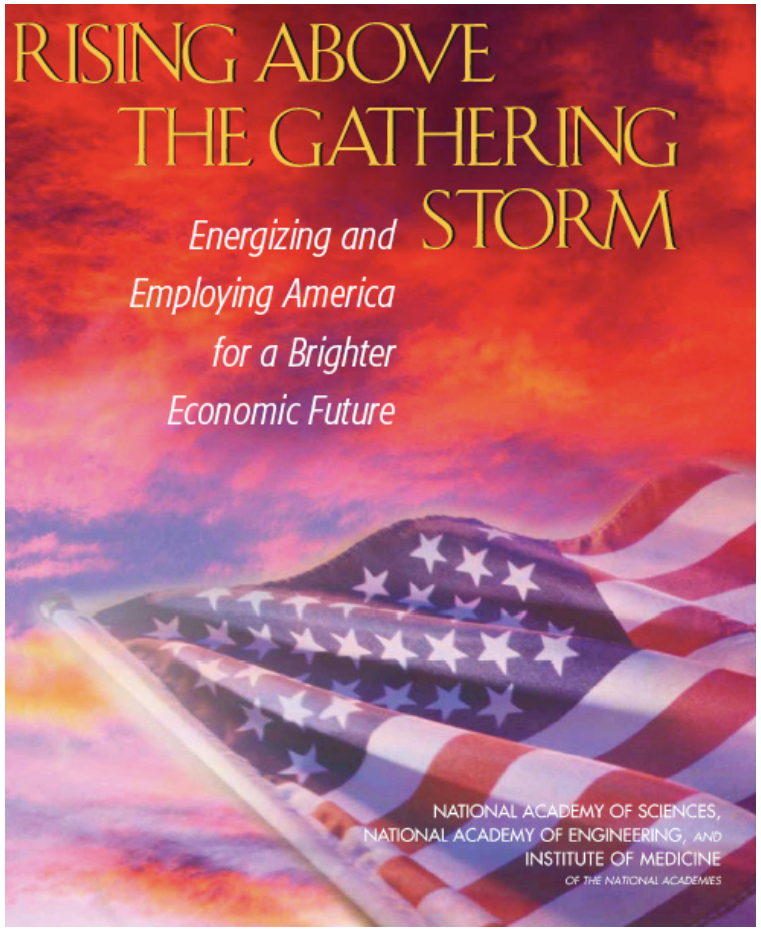
- A mix of 100 people in 2020 would look like the following:
  - 56 would be from Asia, including 19 Chinese and 17 Indians
  - 13 would be from the western hemisphere, including 4 from the United States
  - 16 would be from Africa, including 13 from Sub-Saharan Africa
  - 3 would be from the Middle East
  - 7 would be from Eastern Europe and the former Soviet Union
  - 5 would be from Western Europe

# Q4. Which topics should receive increased coverage in the undergraduate engineering curriculum?



# Rising Above the Gathering Storm

- Energizing and Employing America For a Brighter Economic Future
- Frightening Statistics
- Powerful Recommendations

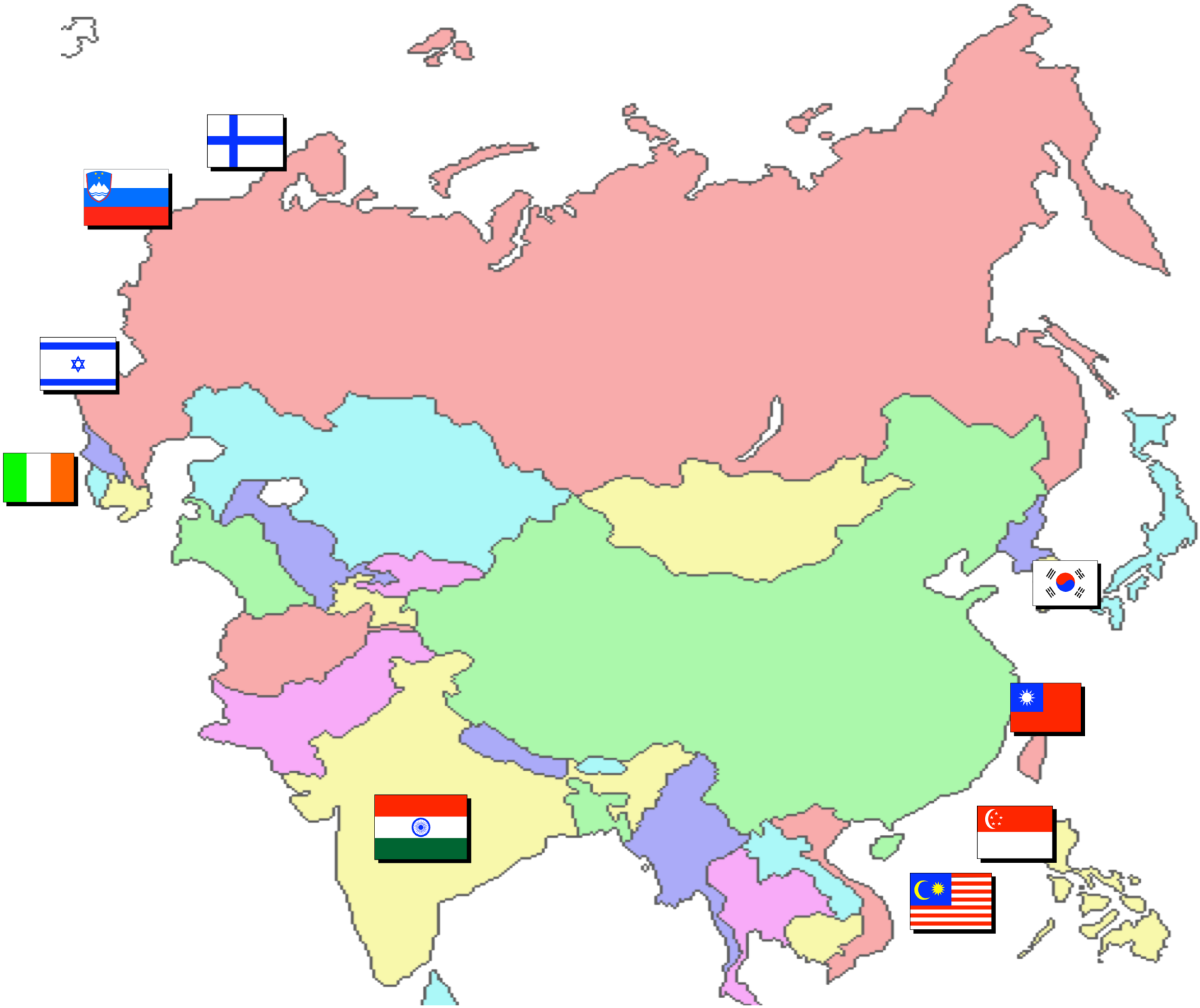


# World Context

- Last year more than 600,000 engineers graduated from institutions of higher education in China
- In India, the figure was 350,000
- In America, it was about 70,000
- South Korea graduates almost as many engineers as the U.S.
- For the cost of one chemist or one engineer in the United States, a company can hire about five chemists in China or 11 engineers in India.

# Workforce Vulnerability

- A quarter of the current science and engineering workforce – whose research and innovation generated the economic boom in the 1990s – is more than 50 years old and will retire by 2020.
- 21% decline in U.S. student population
- Student populations in engineering and physical sciences are static or declining
- 15% decline in foreign-born doctoral students since 1997

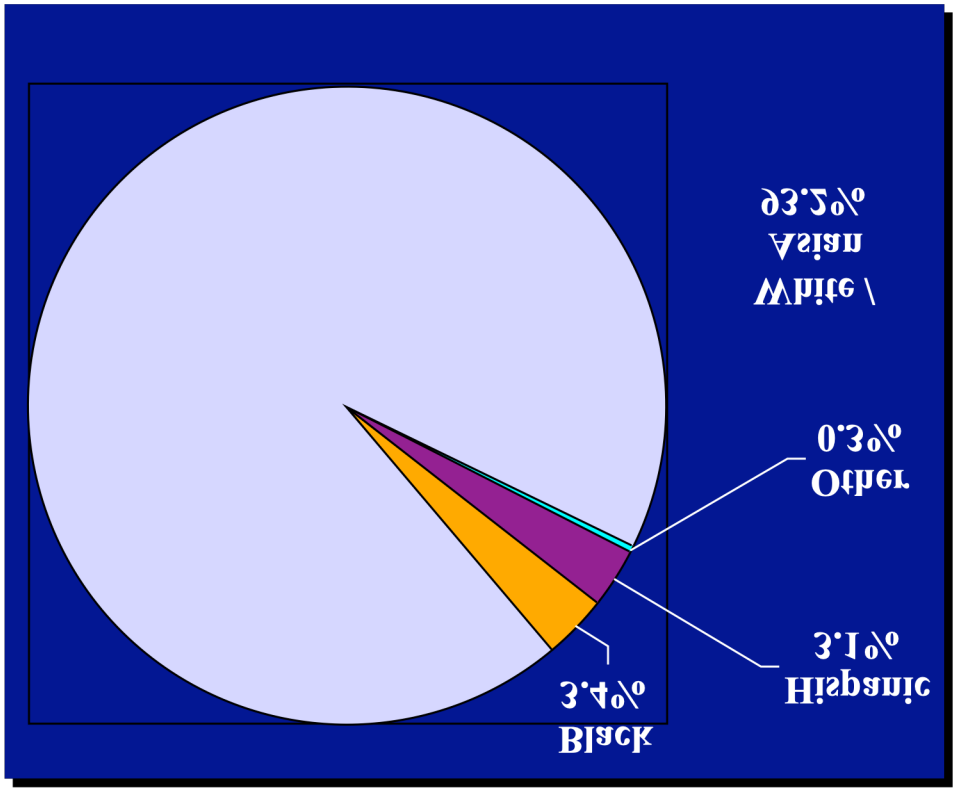


# The Nations New Majority

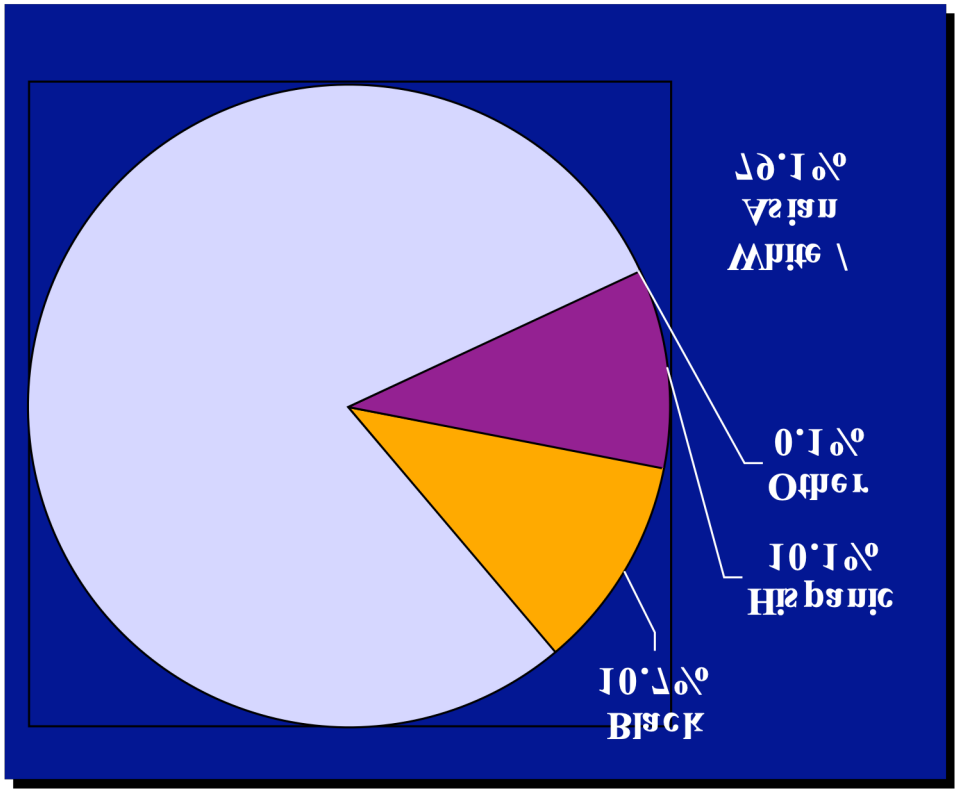
- Women and under-represented groups make up a 1/2 to 2/3 of the population of the United States and comprise the nation's New Majority.
- If the US is to maintain economic leadership and be able to sustain its share of high technology jobs, it must draw on all of the talents in our population . . . Innovation is the key.

Shirley Jackson,
President of RPI

# The Nations New Majority

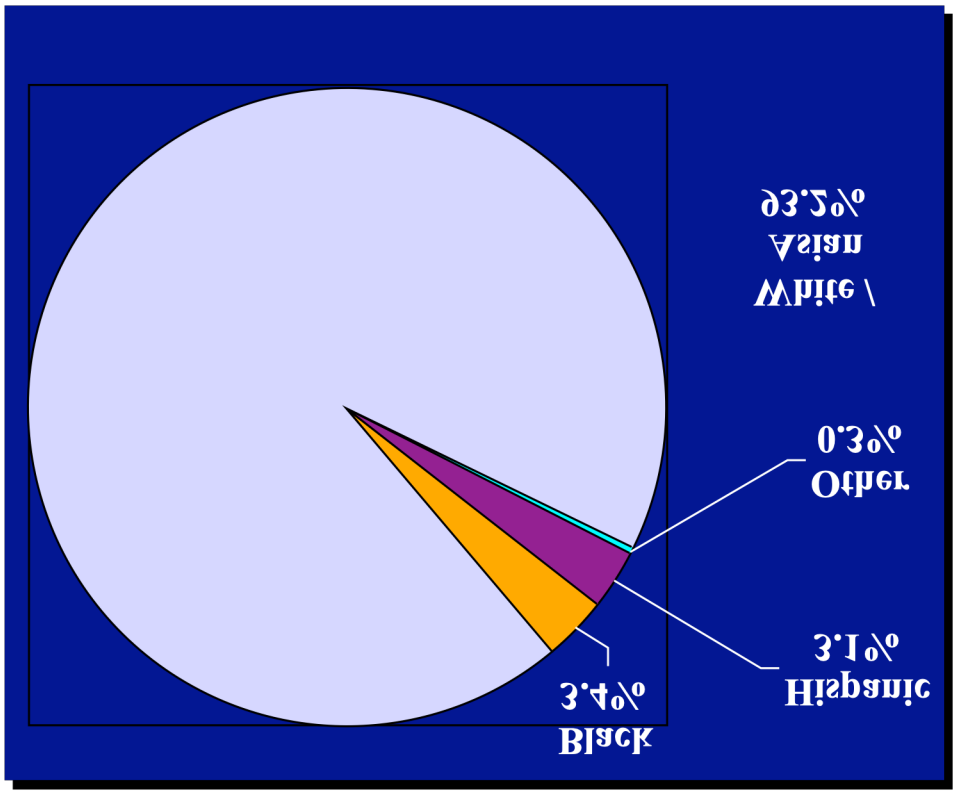


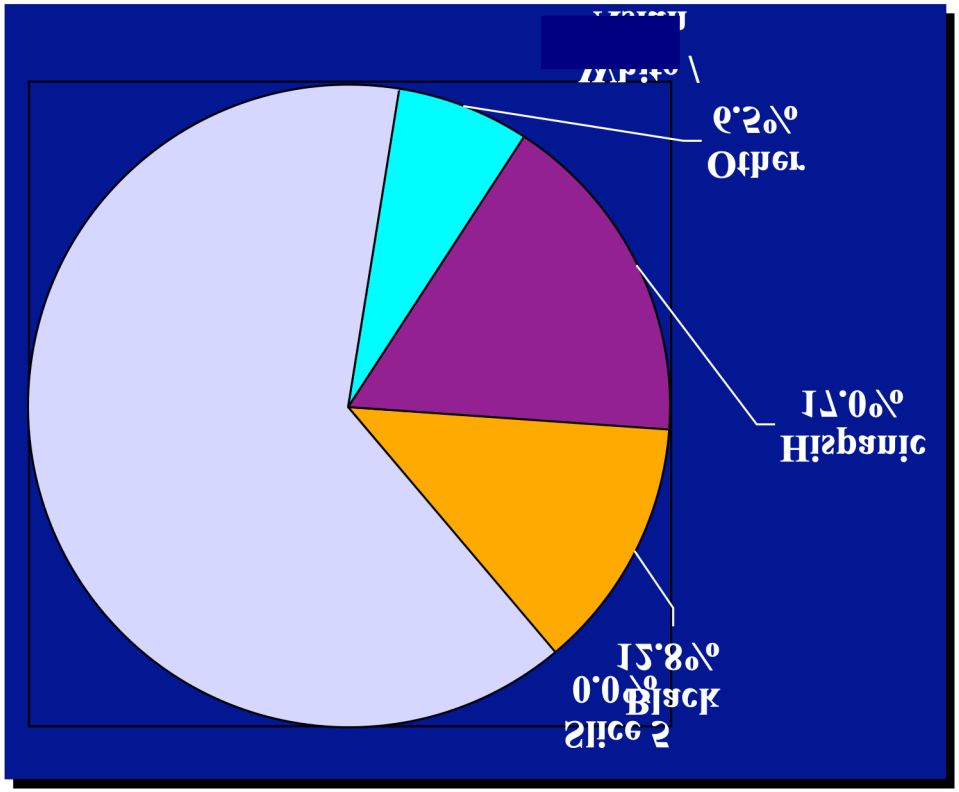

Science and Engineering Workforce




U.S. Workforce

# 2020?

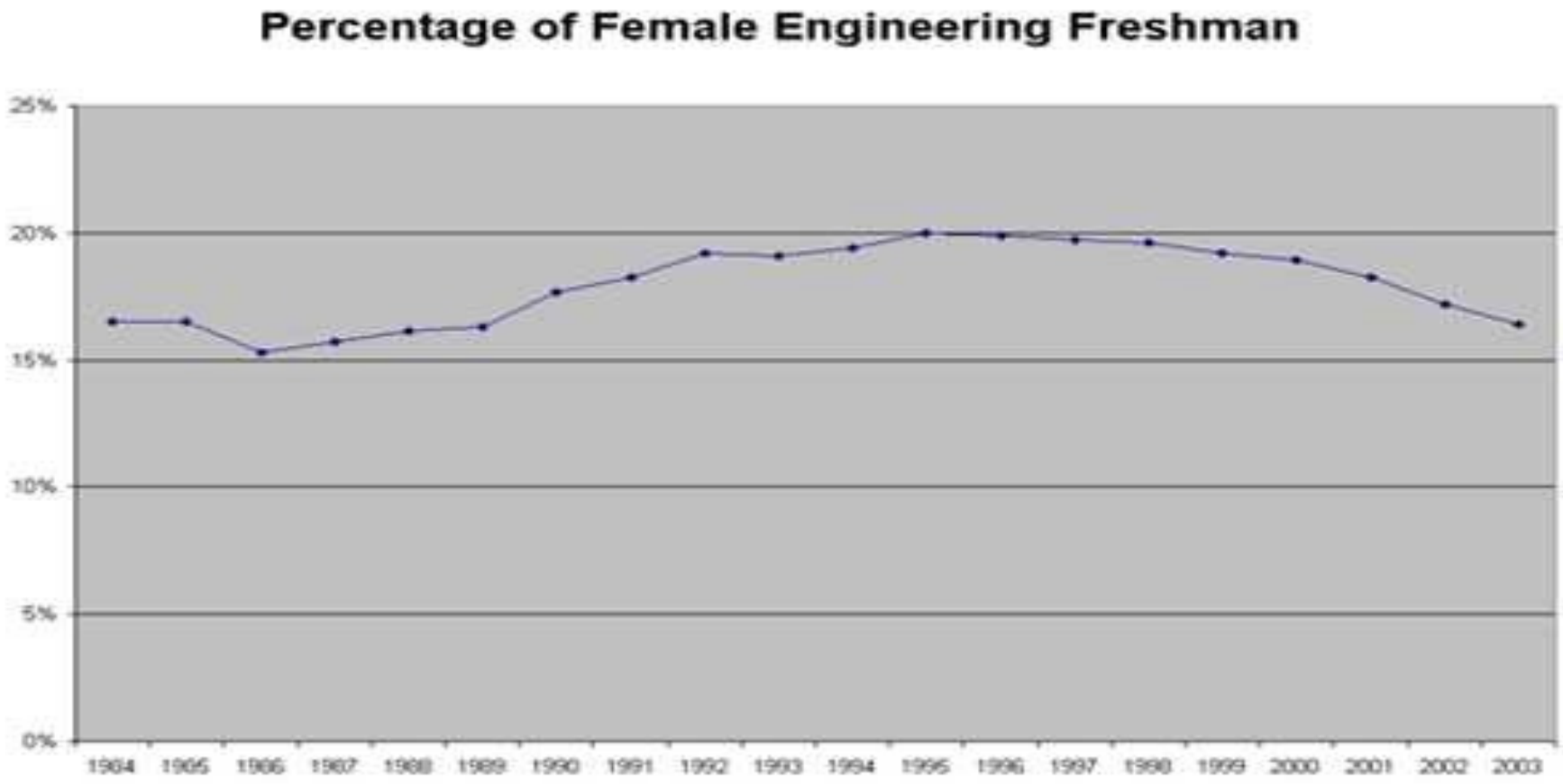


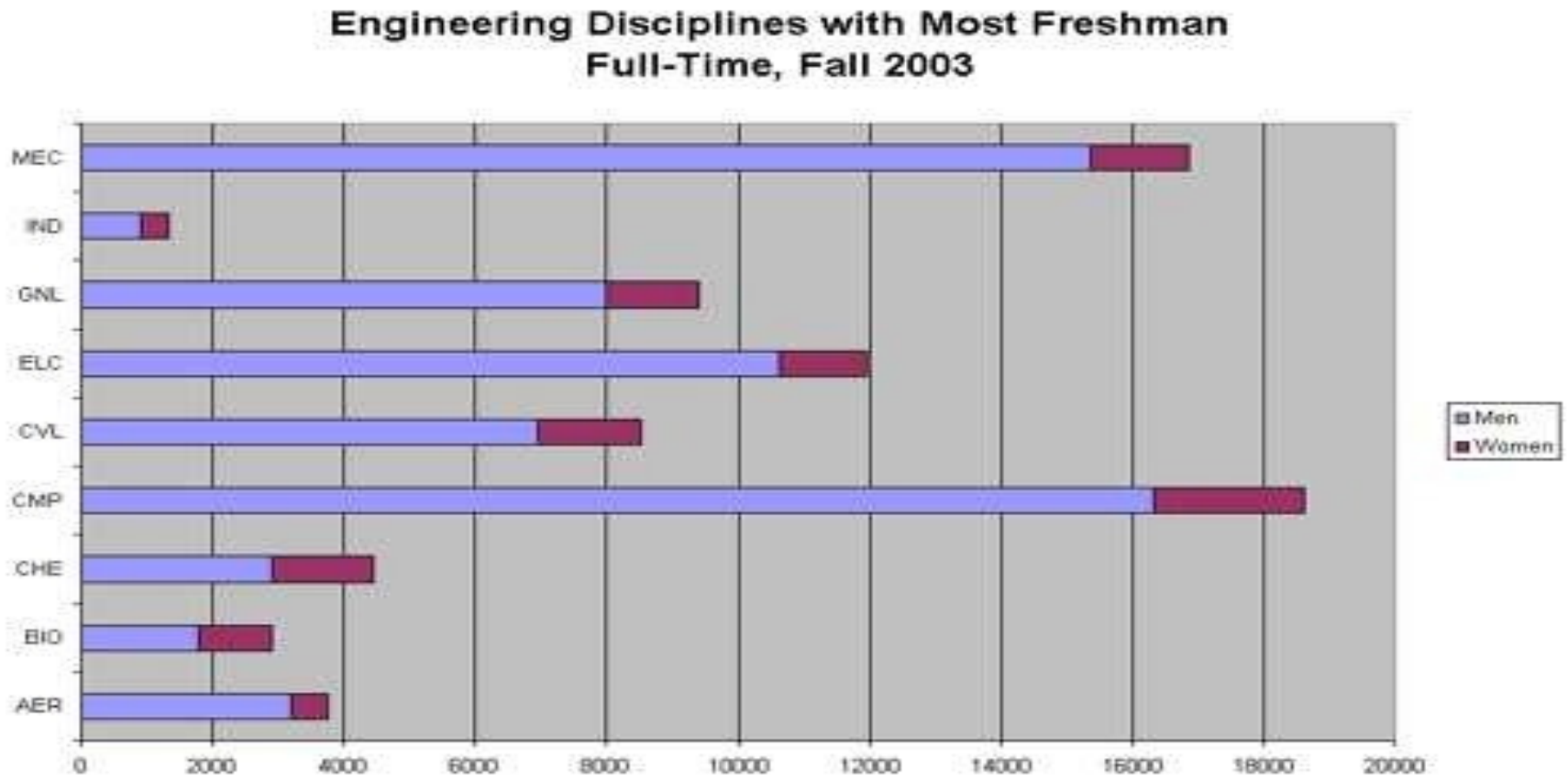

**Science and Engineering Workforce 2000**

**2020 U.S. Workforce**

# Undergraduate Women Engineers



# Distribution by Discipline



# Undergraduate Statistics at ME-UC Berkeley

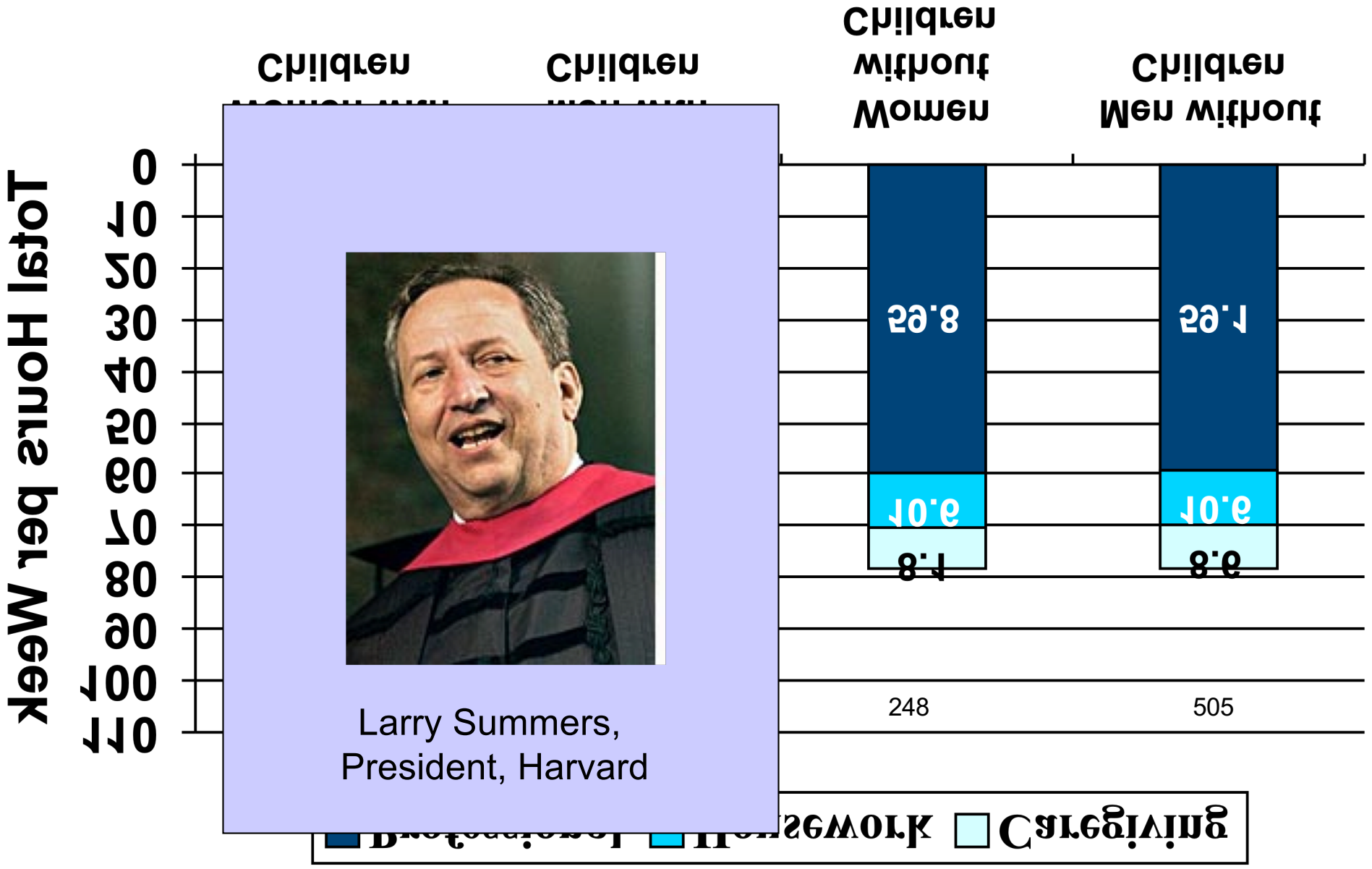
| Year | % Women |
|---|---|
| 1999 | 16.2 |
| 2000 | 19.5 |
| 2001 | 14.7 |
| 2002 | 16.0 |
| 2003 | 13.5 |
| 2004 | 9.5 |

# Themes from Woman & Minority Focus Group

- A change in the culture of engineering (practice) is desired
  - Less unrewardingly competition, more collaboration
  - Changes in the types of problems we *decide* to solve
  - Diversity and quality are seen as complementary
  - Greater value placed on family issues (women)
  - More equitable access to engineering careers (minority)
- Strategies to get there
  - Radical change in the power structure (as it relates to who decides what problems are important)
  - Decision-makers represent a more diverse group
  - New strategies for assessment; more equitable K-12 preparation; allow alternative paths into the profession

# Need for Family Friendly Policies

*(UC Faculty, ages 30-50)*



# Diversity Benefits in Research & Design

- Research shows that diverse working groups are more productive, creative, and innovative than homogeneous groups.
- A study of innovation in corporations found that the most innovative companies deliberately established diverse work teams (Kanter 1983).

# Diversity Benefits in Research & Design

- A controlled experimental study of performance in a brainstorming session compared the ideas generated by ethnically diverse groups composed of Asians, blacks, whites, and Latinos to those produced by ethnically homogenous groups composed of whites only.
- Evaluators, who were unaware of the source of the ideas, rated the ideas produced by diverse groups as being of higher quality using measures of feasibility and effectiveness (Cox 1993; McLeod, et al. 1996).

# Diversity Benefits in Teaching, Research & Design

- The level of critical analysis of decisions and alternatives was higher in groups that heard minority viewpoints than in those that did not, regardless of whether or not the minority opinion was correct or ultimately prevailed.
- Minority viewpoints stimulated discussion of multiple perspectives and previously unconsidered alternatives (Nemeth 1985, 1995).

# Diversity Benefits in Teaching, Research & Design

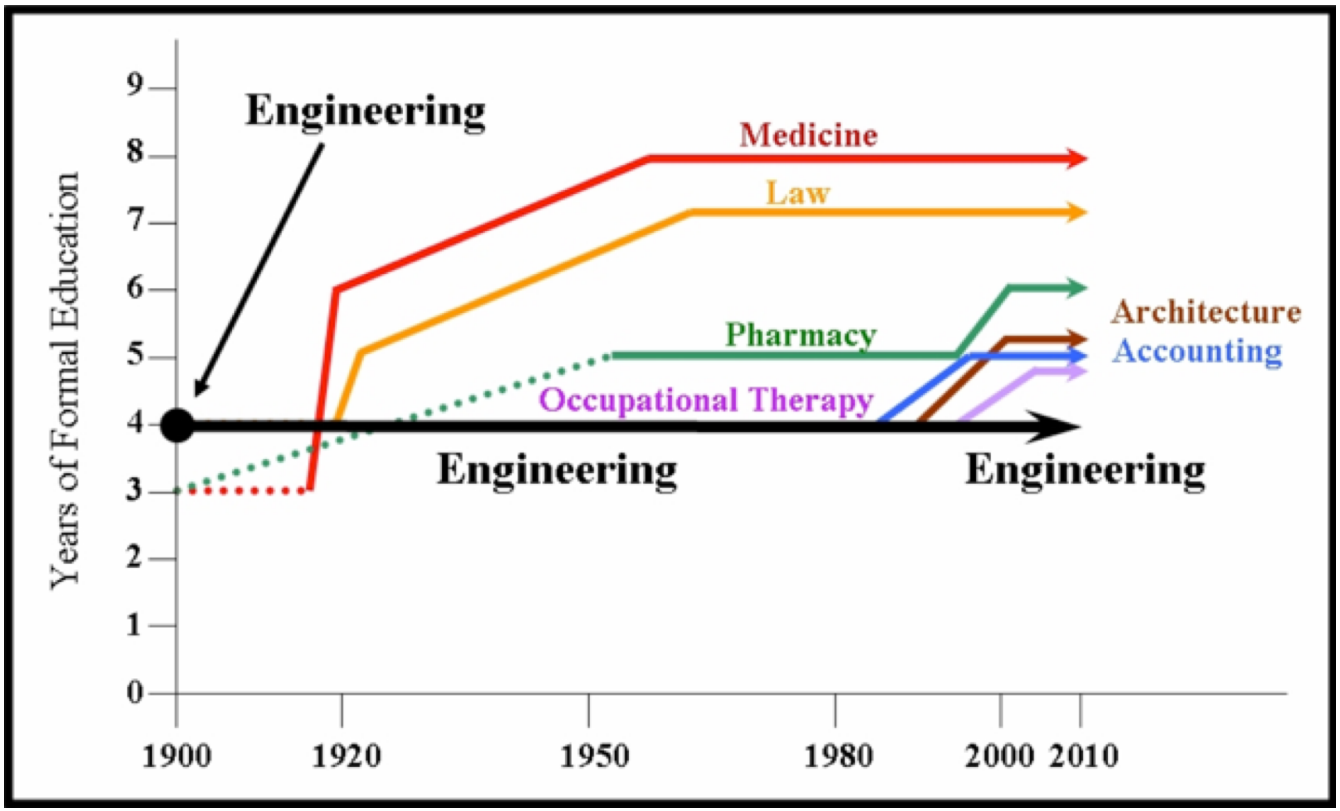
- Using data from the 1995 Faculty Survey conducted by the Higher Education Research Institute (HERI) at UCLA, another study documented that scholars from minority groups have expanded and enriched scholarship and teaching in many intellectual disciplines by offering new perspectives, and raising new questions, challenges, and concerns (Antonio 2002; see also Turner 2000, Nelson and Pellet 1997).

# Diversity Benefits in Teaching

- Several research studies found that women and faculty of color more frequently used active learning in the classroom, encouraged student input, and included perspectives of women and minorities in their course work (Milem 2001).
- This research suggests that developing a diverse faculty will enhance teaching and research (Milem 2001).

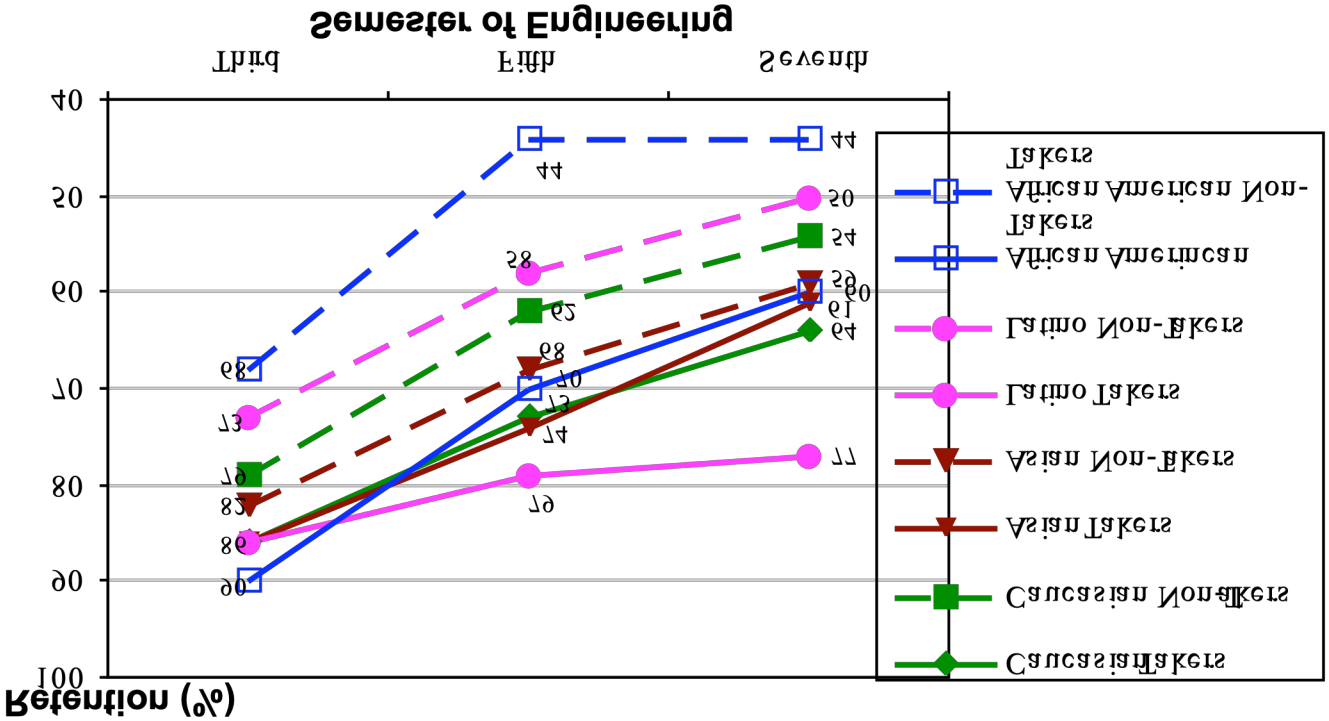
# Engineer 2020
# Access and Professionalism

Should the baccalaureate degree should be recognized as the "pre-engineering" degree (BA or BS), depending on the course content and reflecting the career aspirations of the student.



# Student Retention

- Universal agreement that the process of designing, building and testing – should be taught from the earliest stages of curriculum, including the first year. Student learning outcomes and retention increases.




– Knight, Carlson, & Sullivan, "Staying in Engineering", 2003 (available at www.needs.org)

# What is Preferable

- We must rethink engineering education and make it more attractive and meaningful to young and diverse Americans
- We need family friendly work policies
- We need to remove all gender discrimination
- We must rethink our funding priorities for R&D in the physical sciences and engineering
- ?

# www.needs.org

## (National Engineering Education Digital-library System)

"Engineer 2020"