The Geosciences Workforce: Questions and Challenges

Tim Killeen
Assistant Director for Geosciences
National Science Foundation
17 October 2008
What is GEO at NSF?
What Is Our Mission?

- Support research in the atmospheric, earth, and ocean sciences
- Address the nation’s need to understand, predict, and respond to environmental events and changes in order to use the Earth’s resources wisely
Who Are We?

NSF GEO Staff (FY 2008)
• Managerial Staff: 15
• Science Staff: 70
• Administrative Staff: 37
• Technical Staff: 5

GEO Budget (FY 2007)
• Total: $745.85
• ATM: $227.44
• EAR: $152.83
• OCE: $308.76
• GEO-wide: $56.8

GEO Budget (FY 2008)
Total (est.): $752.66

GEO External Community (FY 2007)
• Principal Investigators: 1,243
• Co-PI’s: 709
• Post-doctorates: 265
• Graduate Students: 1,109
• Undergraduate Students: 647

Funding Profile (FY 2007)
• Competitive Proposals: 3,804
• Competitive Awards: 1,038
• Funding Rate: 27%
Ocean Sciences
- Physical Oceanography
- Biological Oceanography
- Chemical Oceanography
- Marine Geology and Geophysics
- Oceanographic Technology
- Ocean Drilling Program
- Major Facilities (Academic Fleet, etc.)

Earth Sciences
- Paleobiology, Sedimentary Geology
- Geophysics & Geochemistry
- Tectonics & Continental Dynamics
- Hydrologic Sciences & Geomorphology
- Geobiology
- EarthScope Program
- Major Facilities (IRIS, etc.)

Atmospheric Sciences
- Meteorology
- Climate Dynamics and Paleoclimate
- Atmospheric Chemistry
- Aeronomy
- Magnetospheric Physics
- Solar-Terrestrial Physics
- Major Facilities (NCAR, Incoherent Scatter Radars, etc.)

GEO-wide programs including
- GEO Education
- Opportunities for Enhancing Diversity in the Geosciences
- Emerging Topics
- Dynamics of Coupled Natural and Human Systems
GEO’s Investments in Education & Diversity

Emphasis Areas:

• Integrating Geoscience Research and Education
• Developing the Future Geoscience Workforce
• Strengthening Geoscience Education
• Broadening Participation in the Geosciences
• Promoting Public Literacy in the Geosciences
• Fostering Innovative Geoscience Education Research
Integrating Geoscience Research and Education

- GLOBE Program Earth System Science Projects
- Research Experiences for Undergraduates
- Research Experiences for Teachers
- MREFC and STC E&O Activities
  - EarthScope
  - SAHRA
  - NCED
Developing the Future Geoscience Workforce

- CAREER
- EAR Post-doctoral Fellowships
- Early career networks (e.g., DISCCRS, MYRES, MGLS)
- Mentoring programs (e.g., SOARS, RESESS, MS PHD’S)
- Preparing Future Faculty / On the Cutting Edge Resources
- Regional grants conferences
Strengthening Geoscience Education

- Professional Development for Teachers (GEO-Teach)
  - Earth System Science Education Alliance (ESSEA)
  - Transforming Earth System Science Education (TESSE)

- Digital Library for Earth System Education (DLESE)
  - www.dlese.org

- Science Education Resource Center (SERC)
  - serc.carleton.edu

- Innovative, hands-on curricula

- Resources for informal science educators
GEO supports an array of programs that provide K-20 students with research experiences in the geosciences, mentoring, networking, and leadership professional development.
Earth System Science Literacy Initiative

• Multi-Agency effort to identify the Big Ideas that all citizens should know
• Developed through broad input from scientific and education communities
• Used to provide consistency in development of resources and curricula
• Literacy frameworks now available for several geoscience sub-fields:
  • Ocean Literacy (2005)
  • Climate Literacy (under review by CCSP)
  • Atmospheric Science Literacy (2008)
  • Earth Science (terrestrial) Literacy (comment period; due early 2009)

Next Steps:

Integration into one framework for Earth System Science Literacy

Developing a road map for reform of national Earth System Science education
Fostering Innovative Geoscience Education Research

• Linking education theory, pedagogy, and cognitive science with geoscience content to improve:
  • Using visualizations to teach geoscience
  • Using data in the classroom
  • Creating new K-16 curricula
  • Developing spatial thinking skills
  • Addressing common misconceptions
  • Evaluating student learning
Current Funding Opportunities in the GEO E&O Portfolio

• Office of the Assistant Director Programs:
  • Geoscience Education (GeoEd) - $1.5 m/yr
  • Opportunities for Enhancing Diversity in the Geosciences (OEDG) - $4.6 m/yr
  • Geoscience Teacher Training (GEO-Teach) - $3.0 m/yr
  • Global Learning and Observations to Benefit the Environment (GLOBE) - $1.1 m/yr

• Division Programs:
  • Centers for Ocean Science Education Excellence (COSEE)
  • EAR Post-doctoral Fellowship Program
  • Significant Opportunities in Atmospheric Research and Science (SOARS)
  • Research Experiences for Undergrads & Teachers

• GEO also participates in NSF-wide programs:
  • Ethics Education in Science & Engineering
  • ADVANCE, CAREER, GK-12
Workforce & Education Data
• Demographics
• Enrollments
• Baccalaureate Production
• PhD Production & Graduate Enrollment
• S&E Workforce
  – College & University Faculty
The Importance of Demographics

**Predicted Population Demographics**

- **Hisp+/-Any Race**
- **Multi**
- **Nat HI Pac Is**
- **Asian**
- **Am Ind AL Nat**
- **Black**
- **White**

**SOURCE:** Bureau of the Census
U.S. Geoscience Enrollments

SOURCE: AGI
Geographic Distribution of Underrepresented Minorities & Geoscience Departments

As of July 2007, U.S. Census Bureau.


As of 2006, AGI.
Baccalaureate Production: 1996-05

Note: Data are for U.S. citizens and permanent residents only.
SOURCE: NSF
Women as a Percent of Bachelor’s Degrees: 1996 & 2005

Note: Data are for U.S. citizens and permanent residents only.
SOURCE: NSF
Underrepresented Minorities as a Percent of Bachelor’s Degrees: 1996-2005

Note: Data are for U.S. citizens and permanent residents only.
SOURCE: NSF
S&E Baccalaureates by Racial/Ethnic Group: 2005

Natural Sciences

Geosciences

Note: Data are for U.S. citizens and permanent residents only.
SOURCE: NSF
Note: Data are for U.S. citizens and permanent residents only.
SOURCE: NSF
Women as a Percent of Ph.Ds: 1998 & 2005

Note: Data are for U.S. citizens and permanent residents only.
SOURCE: NSF
Underrepresented Minorities as a Percent of Ph.Ds: 1998-05

Note: Data are for U.S. citizens and permanent residents only.
SOURCE: NSF
S&E Ph.D.s by Racial/Ethnic Group: 2005

Note: Data are for U.S. citizens and permanent residents only.
SOURCE: NSF
U.S. Geoscience Employment

1986

- Petroleum: 50%
- Mining: 9%
- Environmental: 7%
- Retired/Unemployed: 10%
- Other: 5%
- Academic: 7%
- Government: 12%

2005

- Petroleum: 43%
- Mining: 12%
- Exec. Management: 1%
- Environmental: 8%
- Other Services: 1%
- Academia: 17%
- Government: 18%

SOURCE: NSF/AGI/BLS
College Graduate Workers in the Mining, Petroleum, and Research Industries

Geoscience Faculty by Rank: 2008


QuickTime™ and a decompressor are needed to see this picture.
Percent of Female Faculty by Rank: 2008

SOURCE: AGI, Geoscience Currents, #9, 3 June 2008.
The Questions
Questions to Ponder

- Workforce Status
- Workforce Development
- Broadening Participation
Workforce Status

• What is the health of the scientific workforce in your discipline?
  – How well do we know the status of our workforce?
  – Is your community losing more professionals than gaining them due to retirements or career changes?
  – Are there enough students and early career faculty in the pipeline?
  – Are there concerns related to participation of non-U.S. students?
  – Are the students we are training getting appropriate jobs? Where?
  – Are students getting the training they need to operate in emerging fields?
  – Should the geosciences consider different mechanisms for student support beyond those tied exclusively to specific research projects?
Workforce Development

• How are professionals in your field working to advance workforce development (beyond traditional graduate and post-doctoral assistantships)?
  – Is there more focus on pre-college education and outreach, undergraduate curriculum and research, and/or broadening participation than in the past?
  – Are we in the geosciences doing enough to strengthen K-12 and public education in the geosciences?
  – Are there enough high quality undergraduate and graduate students in the geosciences pipeline?
  – Are students being trained and mentored appropriately given the direction of the research and the realities of the employment opportunities?
  – How do academic departments need to evolve or adapt to address increasingly interdisciplinary research priorities?
Broadening Participation

• Are we making any progress in diversifying the geosciences?
  – How has your institution changed to address the shifting demographic trends among student populations?
  – Have there been any noticeable changes in the make-up of your student population, in terms of gender and racial/ethnic balance in the past decade?
  – Are mechanisms adequate to attract students from all demographic, educational, and socio-economic backgrounds?
  – Are better strategies needed for recruiting females and underrepresented minorities to join department faculty and retaining them once there?
The Challenges

• Education and Training…
  - Raising student awareness of geoscience education and career opportunities
  - Adapting curricula to better support interdisciplinary research and innovation
  - Broadening participation

• An informed public…
  - Increasing the quality and availability of geoscience education in formal and informal settings
  - Helping scientists better communicate their research

• Competition for Resources…
Earth System Science

• Key Research Challenges
  – Climate change, mitigation and adaptation
  – Scale reduction: regional and decadal
  – Resources and hazards
  – Societal drivers for modeling products
  – Risk and decision making
  – Designed, engineered options

• Key Partners
  – SBE, BIO, ENG, OPP, EHR (Tier 1); CISE/OCI, NIH (Tier 2); Industry foundations (Tier 3)
  – NOAA, NASA, DOE
  – E3, BIN

• Key New Technologies
  – High performance computing
  – Deep Theory
  – High resolution observing networks
  – Virtual organizations – integrative new interactions - synthesis
  – Experimental testing
  – New sensors, ideas
An Action Plan for GEO
A Possible Framework for GEO

- **Theme**
  - "Change and Complexity in Earth Systems (4-DE)"
    - Discovery and transformative science
    - Predictability across scales
    - Building capacity and productivity: developing prototypes

- **Priorities**
  - The Geosciences and Us (workforce, public, teachers, learners, websites)
  - Climate Change (natural and anthropogenic-driven variability, abrupt change, evolution)
  - Dynamic Earth: Weather, Geo-Space, Geo-Dynamics, Oceans and Ecosystem Change
  - Earth-Society interactions and feedbacks: natural resources, hazards and ecosystem services
A Possible Framework, continued.

• Strategic investments
  – Advanced observing networks and platforms, new sensors, data systems, assimilative modeling
  – Decadal, regional earth system modeling and prediction
  – Scaling Bio-Geo processes: crossing spatial, temporal and biological organization scales;
  – Interactions with Social Sciences: valuation, risk and decision making (e.g. water)
  – Petascale collaboratory for Geosciences
  – Earth system science literacy initiatives

• Approaches
  – Partnerships: BIO, SBE, EHR, ENG, OPP, EHR, DOE, NOAA, NASA
  – E&O portfolio analysis: new elements
  – Emergent topic workshops, speaker series
  – Community building (e.g. water cycle in a coupled Geo-Bio systems)
  – International linkages
  – Fostering interdisciplinary science: new approaches
Geosciences and Us

• Theme
  – “It’s Our Planet!”, “Our Dynamic Earth”, “Island Earth”, others?

• Priorities
  – Assemble data on challenges, options, and lessons learned across spectrum
  – Workforce needs analysis (academic, geotechnical, low carbon future)
  – Use GEO PI team as national leadership group
  – K-12 pilots, new approaches, informal and formal, labs, AP, state standards, etc. etc.
  – Community undergraduate curricula developments
  – Build Diversity Now!
  – Finalize literacy efforts and use as launching pad
All Geoscience B.S. (Cyan)
Earth Science B.S. (Yellow)
Meteorology (Blue)
Oceanography (Magenta)