Overview of the Directorate for Mathematical and Physical Sciences

NSF Regional Grants Conference
Hosted by Howard University
Arlington, VA, March 11-12, 2013

Nigel Sharp, nsharp@nsf.gov
Program Director
Division of Astronomical Sciences
NSF Grants Conference

- Transform the Frontiers
- Innovate for Society
- Perform as a Model Organization

- CEMMSS
- CIF21
- E^2
- INSPIRE
- I-Corps
- SaTC
- SEES
NSF Vision and Goals

- **Vision**
  - NSF envisions a nation that capitalizes on new concepts in science and engineering and provides global leadership in advancing research and education

- **Mission**
  - To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense

- **Goals**
  - Discovery
  - Learning
  - Research Infrastructure
  - Stewardship
NSF in a Nutshell

- Independent agency
- Support basic research and education
- Use grant mechanism in two forms:
  - Unsolicited, curiosity driven (majority of $)
  - Solicited, more focused
- Merit review: Intellectual Merit & Broader Impacts
- Support all fields of science/engineering
- Discipline-based structure
- Cross-disciplinary mechanisms
- Support large facilities
NSF Support of Academic Basic Research in Selected Fields
(as a percentage of total federal support)

- All Science and Engineering Fields: 22%
- Engineering: 39%
- Physical Sciences: 48%
- Environmental Sciences: 59%
- Social Sciences: 61%
- Mathematics: 64%
- Biology*: 64%
- Computer Science: 81%

Note: Data shown is for FY 2008, the most recent available at this time. *Includes Biological Sciences and Environmental Biology; excludes NIH.

NSF Organizational Chart

National Science Board (NSB) ➔ Director Deputy Director

Office of the Inspector General (OIG)

Biological Sciences (BIO) ➔ Computer & Information Science & Engineering (CISE) ➔ Engineering (ENG) ➔ Geosciences (GEO) ➔ Mathematical & Physical Sciences (MPS)

Office of Cyberinfrastructure
Office of Equal Employment Opportunity Programs
Office of the General Counsel
Office of Integrative Activities
Office of International Science & Engineering
Office of Legislative & Public Affairs
Office of Polar Programs

Numbers are for Fiscal Year 2012

$718M $653M $829M $886M $1,332M $212M $350M $50M $436M $255M $829M

Budget, Finance & Award Management (BFA)
Information & Resource Management (IRM)
# NSF-Wide Scientific Investments

## Directorates

<table>
<thead>
<tr>
<th>Biological Sciences</th>
<th>Computer &amp; Information S&amp;E</th>
<th>Geosciences (now w/OPP)</th>
<th>Math and Physical Sciences</th>
<th>Social, Behavioral, &amp; Econ Sci.</th>
<th>Education &amp; Human Resources</th>
<th>OIIA (OIA+OISE) OCI (in CISE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CyberInfrastructure Framework for the 21st Century (CIF21)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nano-scale Science &amp; Engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Advanced Manufacturing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Science and Engineering Beyond Moore’s Law</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Networking &amp; Information Technology R&amp;D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Science Engineering &amp; Education for Sustainability (SEES)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Enhancing Access to the Radio Spectrum (EARS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Broadening Participation</td>
</tr>
</tbody>
</table>
To advance science, engineering, and education to inform the societal actions needed for environmental and economic sustainability and sustainable human well-being

» Resilience to natural and technological disasters
» Coastal and Arctic systems
» **Sustainable Chemistry, Engineering and Materials**
» Improvements in IT energy efficiency

**MPS: $27.2M in FY 2013**
Cyber Infrastructure Framework for 21st Century Science and Engineering (CIF21)

- Cyberinfrastructure to transform research, innovation, and education
- Major components
  - Computational and Data-enabled Science
  - Core Technologies, Tools, Algorithms
  - Big Data Projects
  - Workforce Development
  - Partnerships: internal/external

MPS: $19.5M in FY 2013
Cyber-Enabled Materials Manufacturing and Smart Systems (CEMMSS) $50M/MPS

Topological Insulators

- Partnership with ENG and CISE
- Advanced Manufacturing
- DMREF

Materials Innovation Infrastructure

- Fundamental research for discovering, modeling, making, optimizing and manufacturing with new materials and material systems
Secure and Trustworthy Cyberspace (SaTC)

- Cross-foundation partnership to build a cybersecure society
- Produce high-quality digital systems and a well-trained cybersecurity workforce
- *Strategic Plan for the Federal Cybersecurity Research and Development Program*
- Comprehensive National Cybersecurity Initiative (CNCI)

MPS: $2.0M in FY 2013
Research at the Interface of Biological, Mathematical, & Physical Sciences (BioMaPS)

- Adaptive network models
- Biological design strategy for better composite materials
- Computational, Mathematical and Statistical modeling

MPS: $11.6M in FY 2013
Enhancing Access to the Radio Spectrum (EARS)

• Partnership among MPS, ENG, CISE, and SBE
• Cross-cutting research on efficient use of radio spectrum
• Technology, economics, social science, and public policy
• Responsive to national broadband plan

MPS: $12.0M in FY 2013
Supporting Multidisciplinary Research Across NSF

• INSPIRE
  • Track 1/2 (1 was CREATIV)
  • High-risk/high-reward research across disciplines
• I-Corps
  • Business friendly
  • NSF’s first I-Corps award: solar irradiation to dissolve oil contaminants in water
• Science Across Virtual Institutes (SAVI)
  • Virtual Institute for Mathematical and Statistical Sciences (VI-MSS) connects Institutes based in the U.S. and India
# NSF-Wide Programs

<table>
<thead>
<tr>
<th>Directorates</th>
<th>Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Sciences</td>
<td>CAREER</td>
</tr>
<tr>
<td>Computer &amp; Information S&amp;E</td>
<td>ADVANCE</td>
</tr>
<tr>
<td>Engineering</td>
<td>RCN</td>
</tr>
<tr>
<td>Geosciences (+ OPP)</td>
<td>GRFP &amp; IGERT</td>
</tr>
<tr>
<td>Math and Physical Sciences</td>
<td>REU, RET</td>
</tr>
<tr>
<td>Social, Behavioral, &amp; Econ Sci.</td>
<td>GOALI &amp; I-Corps</td>
</tr>
<tr>
<td>Education &amp; Human Resources</td>
<td>RUI, ROA</td>
</tr>
<tr>
<td>Office of Int’l &amp; Integ. Activities</td>
<td>EESE</td>
</tr>
<tr>
<td></td>
<td>EPSCoR</td>
</tr>
</tbody>
</table>
CAREER Program

- NSF's most prestigious awards for junior faculty.
- Awardees are selected based on their plan of outstanding research, excellent education, and the integration of research and education within the context of the mission of their organizations, building a firm foundation for a lifetime of leadership.
- Increased participation of those traditionally under-represented in science and engineering is encouraged.
To make discoveries about the Universe and the laws that govern it;
To create new knowledge, materials, and instruments which promote progress across science and engineering;
To prepare the next generation of scientists through research, and to share the excitement of exploring the unknown with the nation.
Directorate for Mathematical and Physical Sciences (MPS)

- Division of Astronomical Sciences: $240M
- Division of Chemistry: $238M
- Division of Materials Research: $304M
- Division of Mathematical Sciences: $236M
- Division of Physics: $280M

Office of Multidisciplinary Activities: $35M

Numbers are for Fiscal Year 2012
Astronomical Sciences (AST)

- From the Big Bang to DNA
  - Origin and evolution of the Universe
  - Origin and evolution of galaxies
  - Origin and evolution of planetary and stellar systems

- National astronomy portfolio
  - Three agencies – NSF, NASA, and DoE – and international partnerships
  - Strong tradition of private funding
  - NSF assigned federal stewardship of ground-based astronomy
  - Includes open-access facilities and mission-free unrestricted grants

AST has a strong program in Education and Special Programs (including a major investment in post-docs)
Discovery of accelerating universe/Dark Energy by two groups
  » Winners: Brian Schmidt, Adam Riess, Saul Perlmutter

AST Individual Investigator awards
  » Over a dozen awards to Robert Kirshner at Michigan, then Harvard for studies of supernovae in 1980s and 1990s
    » Schmidt and Riess were graduate students at Harvard in 1990s when key work was done
  » Grants to other co-authors also supported the work

National facilities
  » Key supernova identifications for both groups from Cerro Tololo Interamerican Observatory (part of National Optical Astron. Obs.)
    » Confirming/supporting observations at Kitt Peak, Gemini
  » NSF Center for Astroparticle Physics at UC Berkeley provided some of the support for Perlmutter’s group
Major CAREER and REU support
Centers program growing
Collaborations with NIH and DOE
Critical areas of research:
- Sustainability
- CyberInfrastructure
- Energy, Element and Molecule Recycling
- Designed Emergent Behavior
- Imaging the Ultrasmall
Materials Research (DMR)

DMR Programs

● Eight Major Areas:
  » Ceramics, Electronic and Photonic Materials, Metals and Metallic Nanostructures
  » Condensed Matter Physics, Condensed Matter & Materials Theory
  » Biomaterials, Polymers, Solid-State and Materials Chemistry

● Materials Research Science and Engineering Centers

● National Facilities and Instrumentation

● Office of Special Programs
  » International collaboration
  » Education

DMR supports a wide breadth of science – fundamental research to the development of technological applications.
Materials Research (DMR)

• Key disciplinary research areas
  » Unsolicited programs continue to cover the eight major areas of materials research
  » Designing Materials to Revolutionize our Future (DMREF) – an opportunity to combine theory, data and experiment

• Key interdisciplinary research areas
  » Interface of Bio and Physical Sciences
  » Sustainability
    – Sustainable Chemistry, Chemical Engineering and Materials Research (SUSCHEM)
  » Nanoscience and Nanotechnology
  » Advanced Manufacturing
Mathematical Sciences (DMS)

“Core business:” single investigator and group proposals through targeted solicitations
Covers the entire mathematical spectrum

Institutes: 5 NSF-initiated, support for 3 others
  » Visitors to long term programs, workshops

Workforce: responding to a major challenge.
  » EMSW21 training grants
  » Postdoctoral fellowships
  » Research for Undergraduates

In addition to the fundamental research in mathematical sciences, DMS plays an enabling role of all other sciences; DMS has been successful in partnering with other NSF Divisions and Directorates and with other government agencies.
Mathematical Sciences (DMS)

Priorities

**Disciplinary**
- Algebra and Number Theory
- Analysis
- Applied Mathematics
- Combinatorics
- Computational Mathematics
- Foundations
- Geometric Analysis
- Mathematical Biology
- Probability
- Statistics
- Topology

**Interdisciplinary**
- Interface of the Biological and Mathematical Sciences (DMS/NIGMS)
- Algorithms for Threat Detection (ATD)
- Emerging Frontiers in Research & Innovation (EFRI)
- Interaction in Basic and Applied Scientific Research in BIO, ENG & MPS (BIOMaPS)
- Software Infrastructure for Sustained Innovation (SISI)
- CIF21, SEES, INSPIRE, SAVI
Physics (PHY)

Facilities:
LHC, LIGO, IceCube, NSCL, …

Programs:
• Atomic, Molecular, Optical, and Plasma Physics
• Biological Physics
• Elementary Particle Physics
• Gravitational Physics
• Nuclear Physics
• Particle and Nuclear Astrophysics
• Physics at the Information Frontier
• Physics Frontiers Centers
• Theoretical Physics
• Education and Interdisciplinary Programs

PHY collaborates closely with DOE and international partners to support science at large facilities. NSF’s physics portfolio is more diverse than those at any other federal agency.
MPS in a (different) Nutshell

- Largest directorate
  - ~23% of R&RA, ~18% of proposals, FY13 request $1345m
- About half of NSF’s large facilities
- Responsible for the three “core” university disciplines – Physics, Chemistry, Mathematics – and Astronomy and Materials Research
- ~40% of university federal funding in the physical sciences
  - More than 80% in mathematics
  - Federal steward for ground-based astronomy
- Science scope - extension on every scale
  - Femtoseconds and attoseconds to petaseconds and exaseconds
  - From the Planck size to the Cosmic size
  - From nanoKelvin to GigaKelvin
  - From fundamental research to marketable technologies
  - Every mental horizon from n-dimensions to infinity and beyond …
MPS Scientific Opportunities

- Physical sciences at the nanoscale
- Science beyond “Moore’s Law”
- Physics of the Universe
- Complex systems (multi-scale, emergent phenomena)
- Fundamental mathematical and statistical science
- Sustainability (energy, environment, climate)
- Interface between the physical and life sciences
- Computational and data-enabled science and engineering (CDS&E)
Instrumentation

- Both acquisition and development
- Major Research Instrumentation (MRI)
- Divisional instrumentation programs
- Research grants
World Class Major Facilities
Keeping Researchers at the Frontier
Award duration ranges from one to five years (even, though rarely, more), with a mean around three years.
Funding Rates

FY2012

Actions
Awards

AST 18%
CHE 22%
DMR 25%
DMS 34%
PHY 42%

NSF 24%
Merit Review Criteria: Recent Changes

- **Three Principles**
  1. Highest quality: advance, even transform, the frontiers of knowledge.
  2. In aggregate, contribute more broadly to achieving societal goals.
  3. Based on appropriate metrics.

- **Two Criteria** (*unchanged*)
  1. Intellectual Merit
  2. Broader Impact

- **Five Elements**
  1. Potential to advance knowledge & benefit society
  2. Creative, original, or potentially transformative concepts?
  3. Well-reasoned, well-organized, sound rationale, & assessed?
  4. Qualified (individual, team, institution)?
  5. Adequate resources?
Merit Review Criteria: Intellectual Merit

- How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields?
- How well qualified is the proposer (individual or team) to conduct the project?
- To what extent does the proposed activity suggest and explore creative, original, or potentially transformative concepts?
- How well conceived and organized is the proposed activity?
- Is there sufficient access to resources?
Merit Review Criteria: Broader Impacts

- How well does the activity advance discovery and understanding while promoting teaching, training, and learning?
- How well does the proposed activity broaden the participation of underrepresented groups?
- To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships?
- Will the results be disseminated broadly to enhance scientific and technological understanding?
- What may be the benefits of the proposed activity to society?
- **ASK EARLY, ASK OFTEN**
- Read the paperwork (descriptions, solicitations etc.) with care; ask a Program Director for clarifications
- Contact the Program Director(s) to discuss your project: email with 1-2 page description and questions, call, visit
- Be familiar with programs and funded projects
  - Guide to Program: [http://www.nsf.gov/funding/browse_all_funding.jsp](http://www.nsf.gov/funding/browse_all_funding.jsp)
  - Award information, including abstracts: [http://www.nsf.gov/awardsearch](http://www.nsf.gov/awardsearch)
- Know the audience for your proposal review - it **really** is a **competition**!
Know and follow the current Grant Proposal Guide (GPG) - it changes! (data management, postdoc mentoring, bio.sketch contents ... ad infinitum)

Explicitly address Intellectual Merit and Broader Impacts in both the Project Summary and Project Description

Match and justify the budget to the scope of the proposed work - ask for what you need

Submit proposals before the last day/hour!!

Download your completed proposal back to you to check it’s what you sent
What Makes a Strong Proposal?

- New and original ideas \textit{(what?)}
- Sound, succinct, detailed focused plan \textit{(how?)}
- Preliminary data and/or feasibility calculations
- Relevant experience \textit{(why me/us?)}
- Important & timely within field \textit{(why now?)}
- Clarity concerning future direction \textit{(so what?)}
- Well-articulated broader impacts
www.nsf.gov
Get Involved

- Volunteer to be a reviewer and panelist
- Participate in NSF-funded events, workshops, meetings
- Proposals: send your best ideas to NSF
- Get to know your Program Directors
- Keep us informed of your accomplishments
- Work to support collaborative, interdisciplinary research
- Call our attention to things that need improvement
- Suggest strategies to go from basic research to production
- Serve as a program officer ("rotator") or division director

For information on a particular MPS division and program:

http://www.nsf.gov/home/mps

Contact NSF Program Directors for questions & suggestions
Some Useful Web Sites

- NSF: www.nsf.gov
- MPS: http://www.nsf.gov/home/mps
- Guide to Program: http://www.nsf.gov/funding/browse_all_funding.jsp
- Award information: http://www.nsf.gov/awardsearch
- FastLane: https://www.fastlane.nsf.gov
- Data management plan: http://www.nsf.gov/bfa/dias/policy/dmp.jsp
- CAREER: http://www.nsf.gov/CAREER
Ask Early, Ask Often

Nigel Sharp
703-292-4905
nsharp@nsf.gov