

# Graduate STEM Education for the 21<sup>st</sup> Century



# The Issue

- Graduate STEM education is lagging behind the evolution of science and engineering, the nature of the workforce, and the career goals and paths of its students

# The world of science has changed substantially over the last 50-100 years

- The science and engineering workforce is growing
  - Becoming much more diverse
- Over 60% of new Ph.D.'s do NOT go into academic research
  - But we train them the same way we always have
- The nature of science itself has changed

# The nature of science has changed

- The cutting edge is multidisciplinary
  - More and more scientists work in teams
- Science has become global
- What makes a scientific career has changed

# The sponsors

- National Science Foundation
- Institute of Education Sciences
  - US Department of Education
- Burroughs Wellcome Fund
- Spencer Foundation

# The Committee's task:

- A systems analysis of current state of graduate education and career paths
- Identify policies, programs and practices that could better meet the career needs of graduate students
- Identify strategies to improve the alignment of graduate education with the needs of prospective employers and students
- Identify possible changes to federal and state programs and funding priorities
- Identify how best to provide students and faculty with information about career paths
- Identify implications of the increasingly international nature of science
- Investigate the new models that are influencing graduate education

# Committee Members

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# What makes this report different?

- Proposes an ideal graduate education
- Recommends a systems approach to achieving ideal
  - Action steps for every stakeholder
- Urges the system to become more student-centric
  - And provide for an equitable and inclusive environment for a more diverse group of students
- Articulates core competencies at both master's and Ph.D. levels
  - Plus additional career-relevant exploratory experiences
- Confronts the need for culture change
  - Increase emphasis on high quality teaching, advising and mentoring
  - Reduce stigma of non-academic careers
  - Realign academic incentive system

# Some Elements of An Ideal Graduate Education

- Prospective students can select schools based on easy access to outcome data on alumni successes and careers
- Diverse student population can thrive in inclusive, equitable learning environments
- Students acquire core competencies
- Students can explore range of career options
- High quality, trained mentors and advisors
- Students learn to communicate to diverse audiences

# Chapter 2: Data and Trends

## (The Landscape)

- Enrollment, degrees and other general trends
  - Gender
  - Race and Ethnicity
  - Citizenship
  - Disability status
- Some disciplinary breakouts

# Chapter 3: Cross-cutting themes

- Adjusting faculty rewards and incentives
- Increasing data collection, research, and transparency
- Enhancing diversity, equity and inclusion
- Responding to the dynamic nature of 21<sup>st</sup> century STEM
- Optimizing the graduate student experience

# Chapter 4: Core Competencies for the STEM Master's Degree

1. Disciplinary and interdisciplinary knowledge
2. Professional competencies
3. Foundational and transferrable skills
4. Research

# Chapter 5: Core Competencies for the STEM Ph.D. Degree

## ***1. Develop Scientific and Technological Literacy and How to Conduct Original Research***

- a. Deep specialized expertise
- b. Acquire sufficient transdisciplinary knowledge
- c. Identify problems and articulate research questions
- d. Design a research strategy
- e. Evaluate outcomes and iterate as necessary
- f. Adopt rigorous standards of investigation and acquire mastery of skills needed in the field of study
- g. Learn and apply professional norms and practices of the scientific or engineering enterprise

# Chapter 5: Core Competencies for the STEM Ph.D. Degree

## ***2. Develop Leadership, Communication, and Professional Competencies***

- a. Develop ability to work in collaborative and team settings, including with individuals from diverse cultural and disciplinary
- b. Acquire the capacity to communicate in many modes and to both STEM professionals and other audiences
- c. Develop professional competencies needed to plan and implement research projects

# Key Recommendations Relate to:

- Facilitating cultural and behavior change
- Promoting effective teaching and mentoring
- Collecting and sharing national and institutional data on students and alumni
- Ensuring diverse, equitable, and inclusive environments
- Providing for career exploration and preparation
- Ensuring graduate education stays current with relevant trends
- Evolving the structure of doctoral research activities
- Funding for research on graduate STEM education
- Improving the quality of the graduate student experience

# How to Effect Change

- Need for cultural and behavioral changes throughout the system
  - Particularly the incentive system
  - Reduce stigma of non-academic careers
- Specific steps for each stakeholder
  - Summarized by stakeholders in Chapter 6

# Actions for Federal and State Funding Agencies

- Re-align policies and award criteria... whether students supported by research or training grants
- Embed diversity and inclusion metrics in funding criteria
- Require institutions to collect and disseminate data on demographics, funding mechanisms and career outcomes
- Support research to better understand the graduate education system and outcomes of various interventions

# Some other “big” recommendations

- Institutions should develop a uniform, scalable, and sustainable model for data collection.
- Institutions should develop and regularly evaluate strategies to accelerate increasing diversity and improving equity and inclusion.
- Departments should review and modify curricula, dissertation requirements, and capstone projects ... and to provide students with opportunities to work in teams.
- Institutions should integrate professional development opportunities into curricula.
- Industry, nonprofit and other employers should provide guidance and financial support for relevant course offerings at institutions and provide internships and other forms of professional experiences.