American Academy of Environmental Engineers and Scientists
Excellence in Environmental Engineering and Science Awards Luncheon

The Engineering Grand Challenges – Where Environmental Engineering fits into the Landscape of Transformative Research

National Press Club
April 19, 2018
Washington DC

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Chemical, Bioengineering, Environmental and Transport Processes
National Science Foundation
Overview

1. Two Questions
2. NSF Mission, Vision Statement, and 1440 Program Overview
3. The “Standard Model” of Environmental Engineering:
   Inspiration, Concerns, Responses, Successes, and Challenges
4. Grand Challenges for the 21st Century
5. Is past prologue?
6. Q&A
Two questions to ponder...

1. What is the best ROI you have ever heard of?

2. Which profession has saved the most lives?
II) NSF MISSION AND VISION

NSF Statutory Mission

• To promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense; and for other purposes.

—From The National Science Foundation Act of 1950 (P.L. 81-507)

NSF Vision Statement

• NSF envisions a nation that capitalizes on new concepts in science and engineering and provides global leadership in advancing research and education.

—From “Empowering the Nation Through Discovery and Innovation, NSF Strategic Plan for Fiscal Years 2011-2016”

• NSF-funded research must have Intellectual Merit and Broader Impacts
CBET Environmental Engineering: Program Emphasis Areas (1440)

Program Goal: Fund transformational and high risk/high reward research to:

- Prevent/minimize release of pollution to soil, water, and air
- Mitigate: Ecological and human health impacts of such releases by smart/adaptive manipulation of the environment
- Remediate polluted environments through engineered chemical, biological, and geo/physical processes
- Integral to achieving these goals is the fundamental understanding of pollutant transport in the environment and how to harness and control their biological, chemical, and geo/physical reactions
CBET Environmental Engineering (1440)
Program Emphasis Areas

Environmental Chemistry
- Applied Environmental Micro/biology
  - Bioinformatics
  - Applied Environmental Micro/biology
  - Environmental forensics
  - Passive samplers
  - Reactive Membranes
- Digestion
- Bioremediation
- Nutrient Removal
  - Disinfection
- Advanced oxidation
- Emissions
- Emerging Pollutants
- DBPs

Applied Geo/Physics
- Aeration
- Capping
- Desalination
- Transport
- Separations
- Sediment transport
- Environmental catalysis

Environmental Chemistry
- Bioinformatics
- Raw sequences
- Quality Control/Profiling
  - by size, # ambiguous bases, homopolymeric regions
- Alignment to Reference Database (Protein Coding Sequences)

Chandran et al. (2017)

Chaplin (2017)

Li (2008)

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“The words you speak become the house you live in”

-Hafez (1315-1390)

A trip through the Environmental Engineering program abstracts

http://www.iub.edu/~iuam/online_modules/islamic_book_arts/exhibit/manuscripts/divan_hafiz.html
Pre-1990s
2000-2005

Keywords:
- Water
- Environmental Engineering
- Systems
- Processes
- Contaminant
- Disinfection
- University
- Treatment
- Development
- Understanding
- Well
- Radiation
- Particles
- Microorganisms
- Education
- Modeling
- Experiments
- Study
- Use
- Environment
- Soil
- Iron
- Groundwater
- Current
- Knowledge
- Evaluations
- Engineers
- Response
- Sediments
- Sorption
- Carbon
- Bacterial
- Laboratory
- Subsurface
- Focus
- Fields
- Determine
- Chemical
- Applied
- Membrane
- Problems
- Potential
- Technologies
- Organic
- Identify
- Science
- Health
- Undergraduate
- Graduate
- Engineering
- Rates
- Techniques
- Conditions
- Size
- Mechanisms
- Approaches
- Impact
- Bacteria
- Degradation
- Molecule
- Natural
- Program
- Provide
- Workshop
- New
- Fundamental
- Two
- Fate
- also
- Further
- Using
- New
- Rates
- Techniques
2005-2010

environmental

wastewater

engineering

water
2010-2015

wastewater

environmental

water

engineering
2015-present
III) The “Standard Model” of Environmental Engineering
INSPIRATION
RESPONSES

Legislation
• SDWA
• CWA
• CAA
• GLWPA
• CERCLA
• RCRA
• Etc…
...But some of our greatest successes were well before the modern environmental movement

Figures from Cutler and Miller (2004)
National Bureau of Economic Research
Early “Environmental Engineers” helped save millions and increased US lifespan

Data from Cutler and Miller (2004) National Bureau of Economic Research

Completed changed the shape of childhood disease in a few decades
The social ROI: $23 per $1 spent on water infrastructure

Reduction in Mortality 1900-1936

- Child Mortality
- Infant Mortality
- Total Mortality
- Typhoid Mortality

Annual US deaths prevented 1500/100,000

Person-years saved 58,000

Annual benefits (2018 $) $920M

Data from Cutler and Miller (2004)
National Bureau of Economic Research
So where is the love?

I am still waiting for the Environmental Engineer TV show!
IV) Grand Challenges for Environmental Engineers and Scientists in the 21st Century
Grand Challenges for Environmental Engineering and Science in the 21st Century

www.nas-sites.org/dels/eeschallenges #GrandChallenges
Restore and improve urban infrastructure

Good design and advanced materials can improve transportation and energy, water, and waste systems, and also create more sustainable urban environments.

SHAPE THE FUTURE

NAE Grand Challenges Scholars Program

GRAND CHALLENGES IN THE NEWS

View photos and videos from the 2017 Global Grand Challenges Summit!

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http://www.engineeringchallenges.org/
1. Advance Personalized Learning
2. Make Solar Energy Economical
3. Enhance Virtual Reality
4. Reverse-Engineer the Brain
5. Engineer Better Medicines
6. Advance Health Informatics
7. **Restore and Improve Urban Infrastructure**
8. Secure Cyberspace
9. **Provide Access to Clean Water**
10. Provide Energy from Fusion
11. Prevent Nuclear Terror
12. **Manage the Nitrogen Cycle**
13. **Develop Carbon Sequestration Methods**
14. Engineer the Tools of Scientific Discovery
Study charge

• Identify high priority challenges and opportunities for the broad field of environmental engineering for the next several decades

• Identify key questions that require the expertise of environmental engineering & science to address;

• Identify areas where knowledge and practice need to advance to address these challenges

http://nas-sites.org/dels/eechallenges/
Committee Membership

Domenico Grasso – University of Delaware
Craig H. Benson (NAE) – University of Virginia
Amanda Carrico – University of Colorado,
Kartik Chandran – Columbia University,
Wayne Clough (NAE) – Emeritus, Smithsonian Institution; Georgia Institute of Technology
John C. Crittenden (NAE) – Georgia Institute of Technology
Daniel S. Greenbaum – Health Effects Institute
Steven P. Hamburg – Environmental Defense Fund
Thomas C. Harmon – University of California, Merced

James M. Hughes (NAM) – Emory University School of Medicine
Kimberly L. Jones – Howard University
Linsey C. Marr – Virginia Polytechnic Institute
Robert Perciasepe – Center for Climate and Energy Solutions
Stephen Polasky (NAS) – University of Minnesota
Maxine L. Savitz (NAE) – Honeywell, Inc.
Norman R. Scott (NAE) – Cornell University
Rhodes Trussell (NAE) – Trussell Technologies, Inc.
Julie Zimmerman – Yale University
Emerging Pollutants
While legacy pollutants decrease others are taking their place

Hosseini (2016)


Andy Whelton, Purdue Univ (2017)

https://marinedebris.noaa.gov/info/patch.html
Food
How to mitigate food production impacts on the environment


Faradji and de Boer (2016)

Diaz et al (2008)
Climate Change
Not just seas, not just rise!

- Unlike the oceans, Great Lakes **water levels are expected to decrease** due to climate change

- **Societal Impacts:** Changing lake levels impact **infrastructure, resources, and transportation**

Study Impacts
Advancing the Progress of EE&S

- Create new opportunities for relevant education and training
- Identify research gaps to guide fruitful areas of research
- ID ways to integrate social/behavioral aspects for effective solutions (Bluespace, learning from history!)
- Inspire a new generation of EES to “make a difference”
  - Infrastructure vs “earth systems engineer”
  - Developing nations
- Guide educational development to train the profession

Stay tuned for August release

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Other Current National Challenges

• **Opioids:**
  • Pharmaceutical capture, fate, and transport
  • Urine separation

• **Disaster Response:**
  • RAPIDs: Health effects, pollution, water supply
  • Natural Hazards Workshop (U of Colorado in July) w/NIH-NIEHS
  • Resilient Environmental Infrastructure

• **WW Omics for Integrated Public Health Assessment:**
  • Utilize the integrated capture of molecular data in the WW stream to **assess** human health through –omics technologies
These and many other challenges await...

If “past is prologue”, I have every confidence that the profession is up to the task!
Q & A

“Water no get enemy”

-Fela Ransome Kuti (1938-1997)

https://egregores.files.wordpress.com/2010/02/felasax1.jpg