



The NAE Grand Challenge Scholars Program: Update on a White House Call to Action



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Engineering Deans Institute Annual Meeting, Scottsdale

April 8, 2014

Looking Back to the 20th Century:

Greatest Engineering Achievements OF THE 20TH CENTURY

◆ About ◆ Timeline ◆ The Book

Welcome!

How many of the 20th century's greatest engineering achievements will you use today? A car? Computer? Telephone? Explore our list of the top 20 achievements and learn how engineering shaped a century and changed the world.

- | | |
|--|--|
| 1. Electrification | 11. Highways |
| 2. Automobile | 12. Spacecraft |
| 3. Airplane | 13. Internet |
| 4. Water Supply and Distribution | 14. Imaging |
| 5. Electronics | 15. Household Appliances |
| 6. Radio and Television | 16. Health Technologies |
| 7. Agricultural Mechanization | 17. Petroleum and Petrochemical Technologies |
| 8. Computers | 18. Laser and Fiber Optics |
| 9. Telephone | 19. Nuclear Technologies |
| 10. Air Conditioning and Refrigeration | 20. High-performance Materials |



NAE Grand Challenges for the 21st Century



Make solar energy economical



Provide energy from fusion



Develop carbon sequestration methods



Manage the nitrogen cycle



Provide access to clean water



Restore and improve urban infrastructure



Advance health informatics



Engineer better medicines



Reverse-engineer the brain



Prevent nuclear terror



Secure cyberspace



Enhance virtual reality



Advance personalized learning



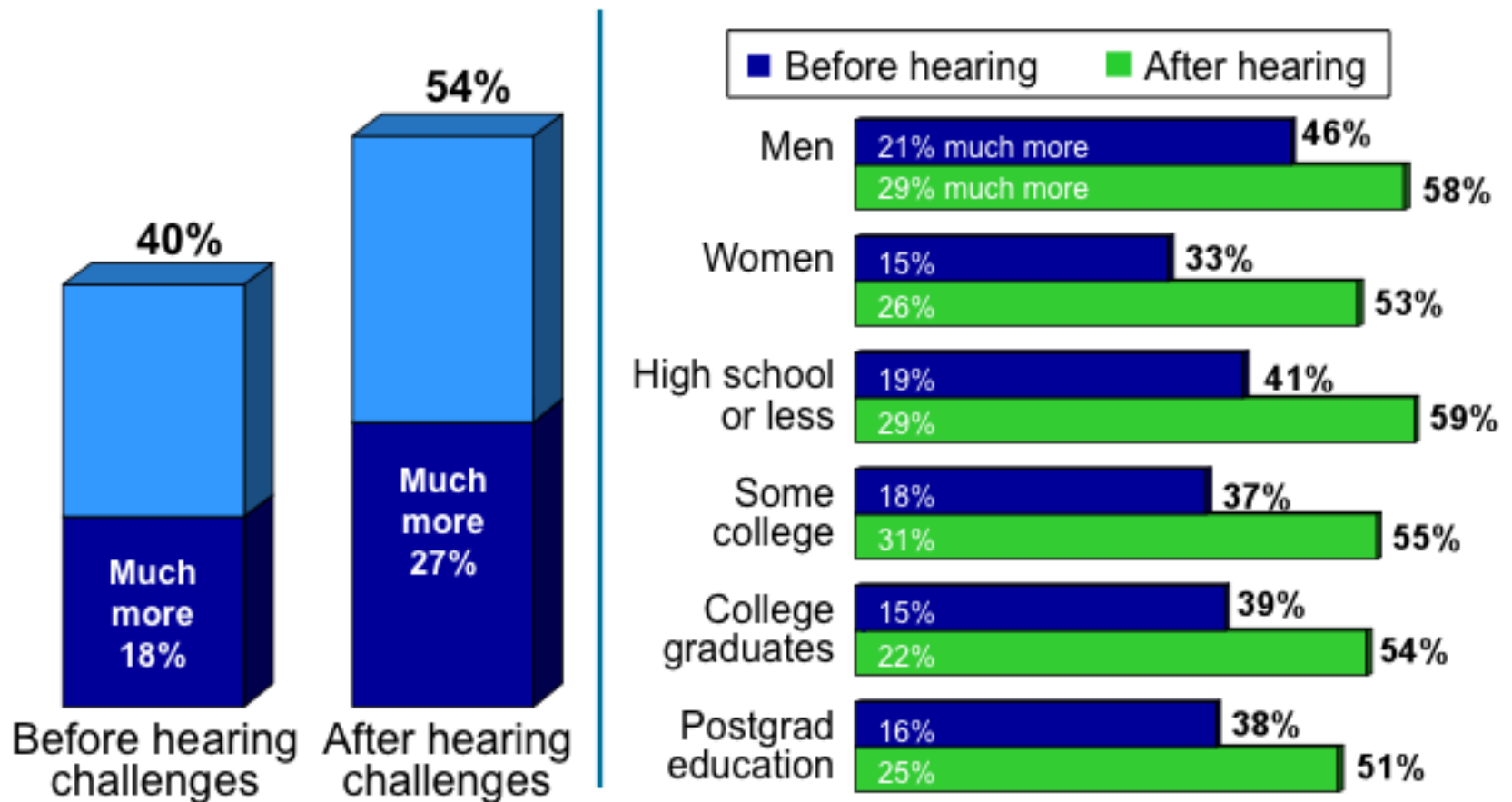
Engineer the tools of scientific discovery

Implications of the Grand Challenges

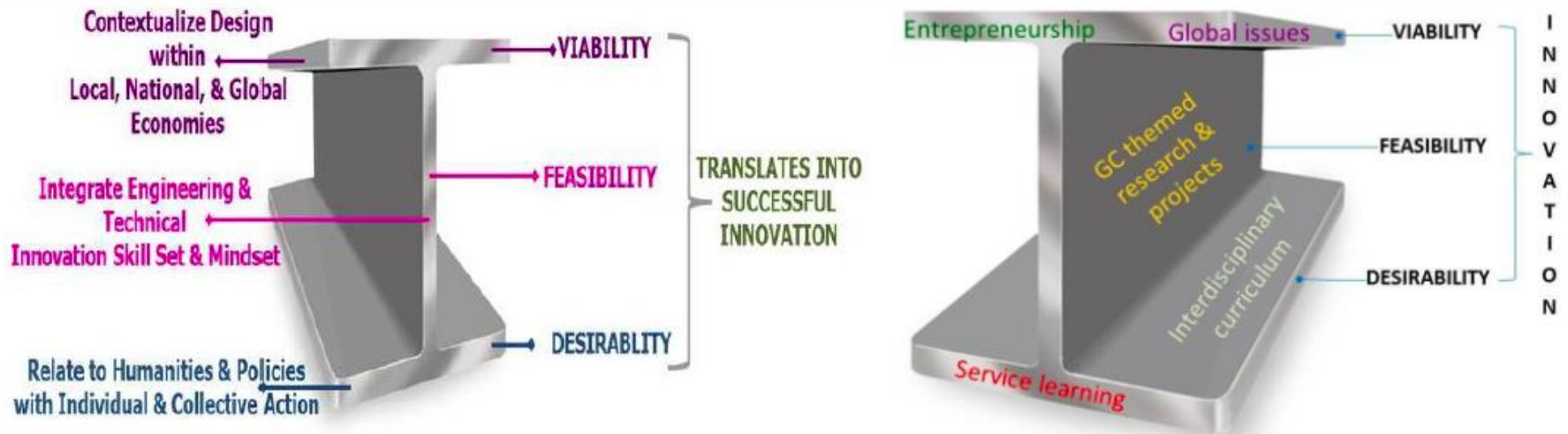
- Don't fit within any one discipline, or even within engineering
- Describe engineering in human-facing terms:
 - Sustainability, Health, Security, Joy
- Powerful tool for “Changing the Conversation”

Learning about NAE challenges enhances perceptions of importance and interest in engineering.

% saying engineering issues/problems are more interesting/important than those of medicine, business, and law



Solving Grand Challenges will require I-Shaped Engineers



Courtesy Christina White, UT

- Solutions must be Feasible, Viable, Desirable
 - Feasible → Engineering fundamentals
 - Viable → Economics and business knowledge
 - Desirable → Context of culture and social policy

A couple of stories...

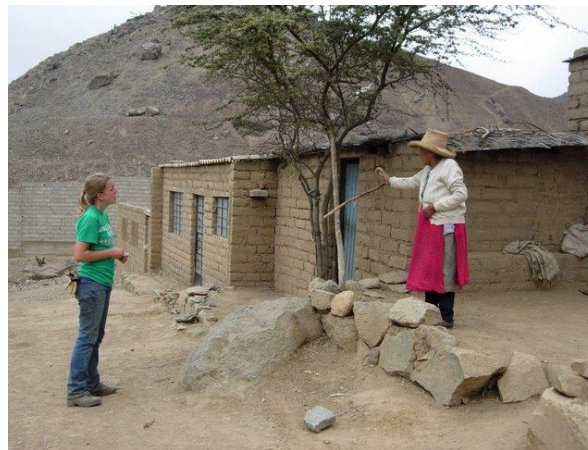
Goals of the Grand Challenge Scholars Program

- Create a generation/community of engineers with the skillset and mindset to solve Grand Challenges
 - “The 300” of ancient Sparta → today
- Attract diverse students to engineering
- Retain “
- Incent students to stretch
- Integrate co-curricular and curricular education into a whole greater than the sum of its parts



Grand Challenge Scholars

- To prepare UG engineering students with the skillset and mindset to address GCs over the course of their careers
- Five critical components
 1. Project or research activity engaging a Grand Challenge
 2. Interdisciplinary curriculum
 3. Entrepreneurship
 4. Global dimension
 5. Service learning



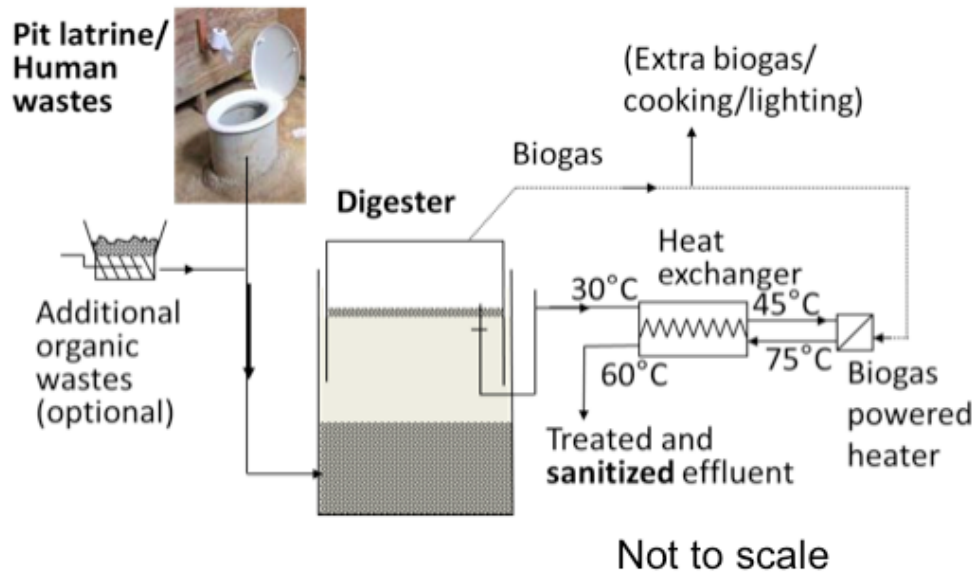
Simon GC
Scholar Maggie
Hoff working on
potable water
project in Peru

Courtesy Martha Absher

Project Example: Revenue-generating Public Toilets in Togo

Reinventing the pit latrine

Human waste digested to biogas,
then used to heat sterilize effluent.





**6 seat prototype in Togo
Biogas combustion to generate electric power and revenue**

Project Example: Sustainable fishery in Kenya

Teaching wave mechanics to protect fragile shallow water reefs



SPECIAL ISSUE

SCIENTIFIC
AMERICAN

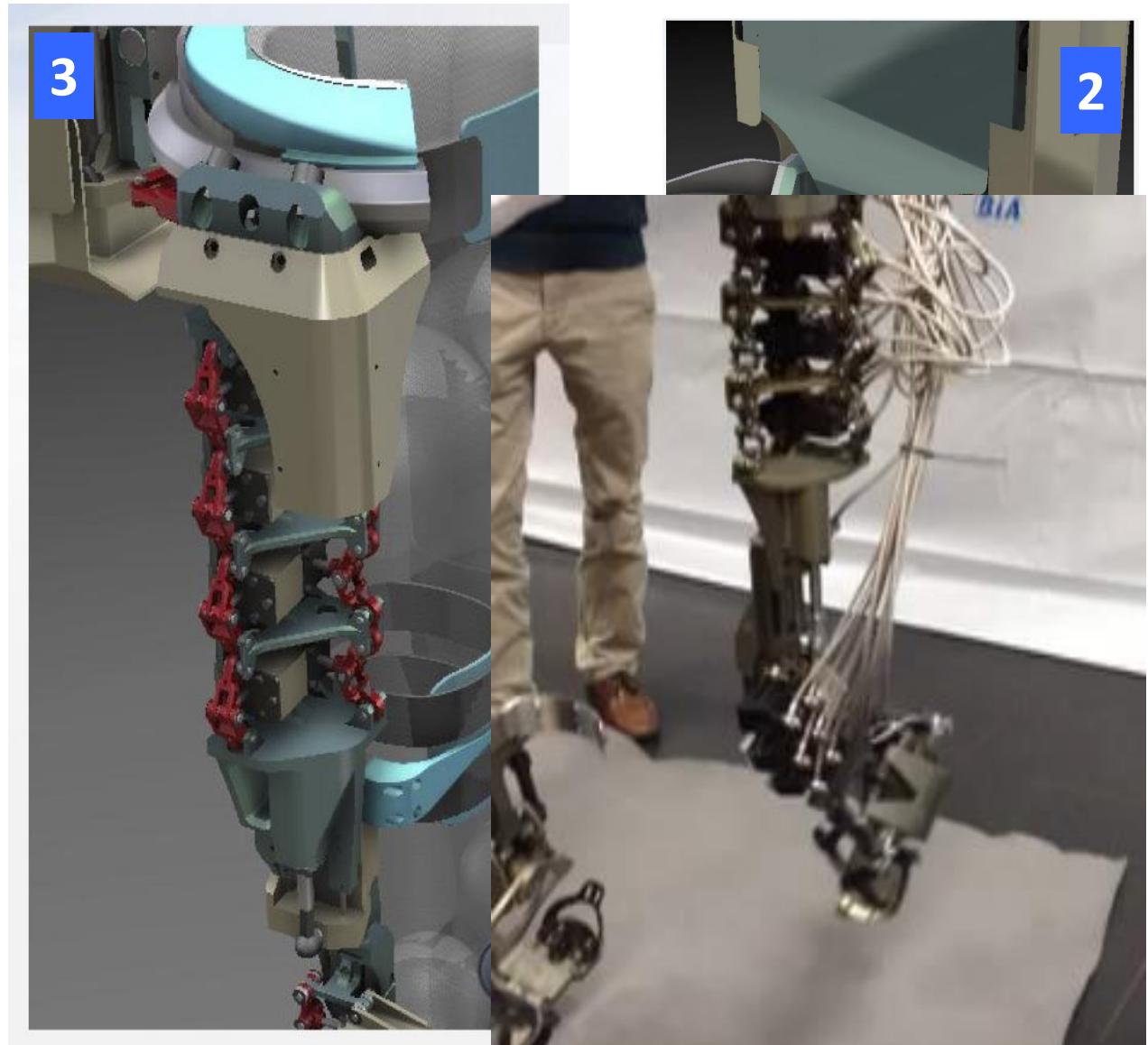
Beyond the Limits of Science

How we will transcend today's barriers to get smarter,
live longer and expand the power of human innovation

World Cup Opening, Brazil 2014



Project Example: Exoskeleton controlled by Brain-Machine Interface



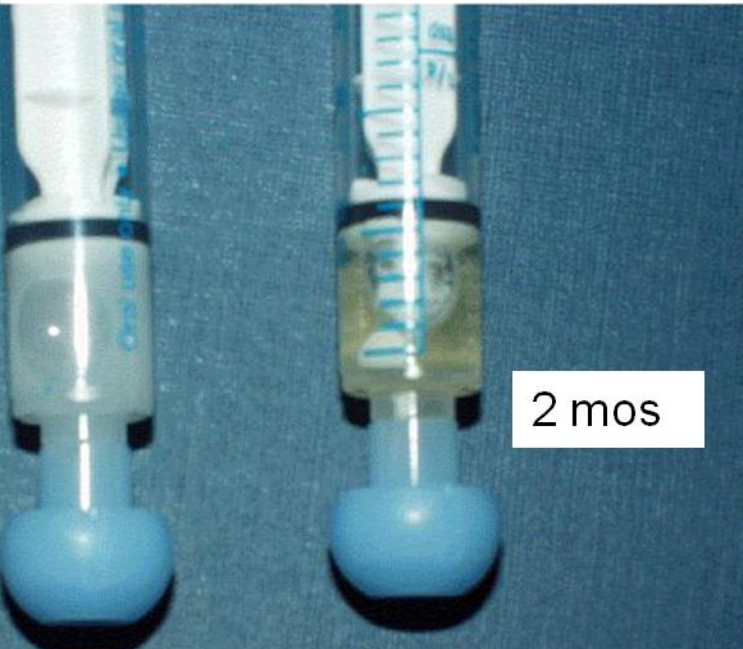
Courtesy M. Nicolelis, Du

Project Example: Pratt Pouch

- HIV+ Women who give birth at home
 - 20-50% have HIV+ children [1]
 - Majority transmitted during delivery [1]
- 3TC, NVP and/or AZT can prevent transmission
 - Drugs expires quickly out of the bottle (<1mos)

[1] WHO (2006) 'Antiretroviral drugs for treating pregnant women and preventing HIV infection in infants in resource-limited settings: towards universal access'

Duke Pouch 12 mos NVP
Duke Pouch 12 mos AZT
Duke Pouch 12 mos 3TC



Clinical Trials
Ecuador
Zambia
Tanzania
Namibia



Courtesy: Bob Malkin

The End Game: Not just education but solutions to Grand Challenges

- Some expected and some unexpected advances since 2007...

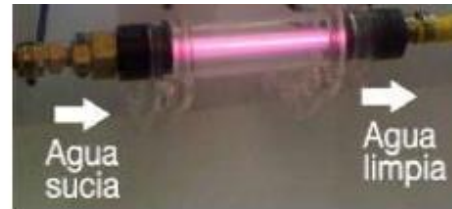
Provide Clean Water



Dean Kamen's Slingshot and Stirling generator



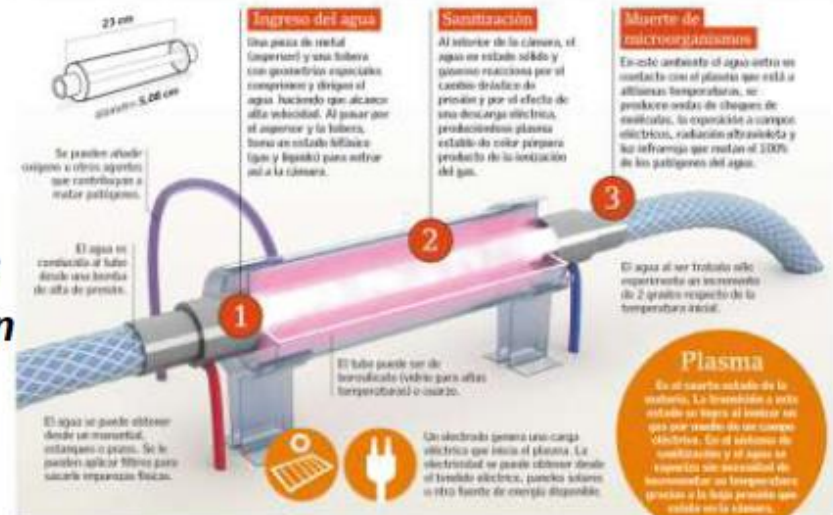
>1,000 liters/day
 <.001 cent per liter
 Less electricity than
 a hairdryer



AIC-Chile Plasma Water Sanitization System

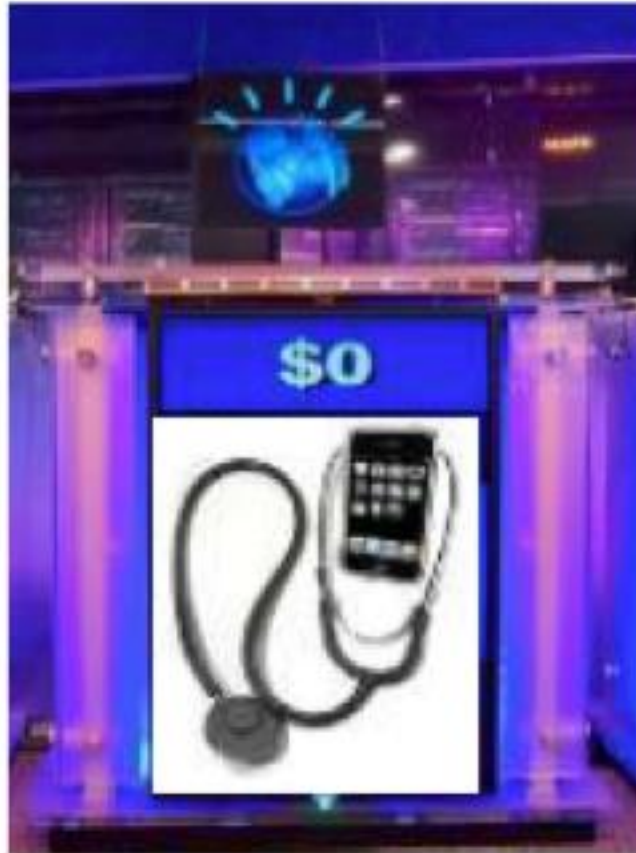
Un tubo que mata los gérmenes del agua

El sistema promete revolucionar la obtención de agua potable en el mundo, sobre todo en áreas afectadas por enfermedades como el cólera. El aparato convierte agua contaminada en un líquido sin presencia de virus, bacterias e microalgas dañinos.



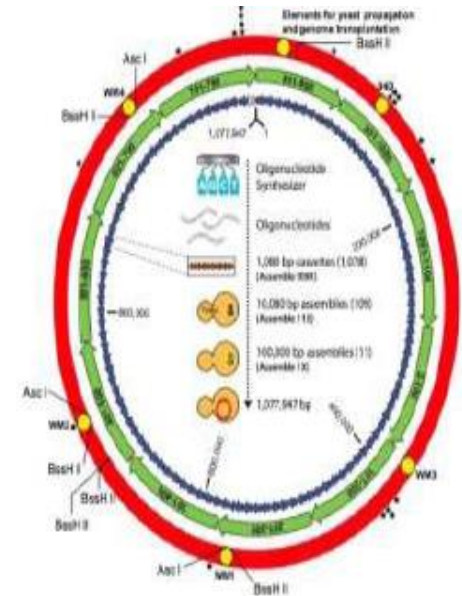
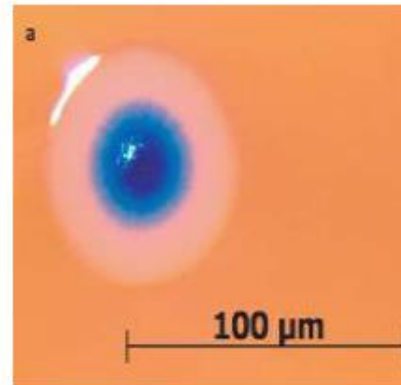
2010:

opardy



2013 IBM Watson as an AI Physician

2010: Make Solar Energy Economical Algae?



May 20, 2010
First synthetic life form



- FUEL
- FOOD
- VACCINES

Algae: 10,000 gal/acre/year

250M Cars → ~0.0048 of US
landmass

Carbon Sequestration

- Ca. 2012: Advent of fracking drives down natural gas costs, replaces coal in fixed power generating plants
- CO₂ emissions reduced 50% from US electricity
- Can we engineer the environmental benefits of fracking?

TECH | 1/11/2013 @ 10:18AM | 3,090 views

Don't sign the wrong fracking petition

Singularity University Affiliate, Contributor

10 comments, 5 called-out

+ Comment Now + Follow Comments

By Tom Katsouleas, Dean of Duke University's Pratt School of Engineering. Named as Chair of the National Academy of Engineering's Advisory Committee on Engineering's Grand Challenges for the 21st Century.



Activists deliver 160,000 signatures against fracking (Photo credit: CREDO.fracking)

Personalized Learning

2011: First MOOC reaches > 100,000

2013



With **Duolingo** you learn a language for free while helping to translate the web

900,000 learners + Machine Learning → surpassing Rosetta Stone

Engr Tools of Scientific Discovery

Laser and beam-driven plasma wakefields can miniaturize a large particle accelerator:



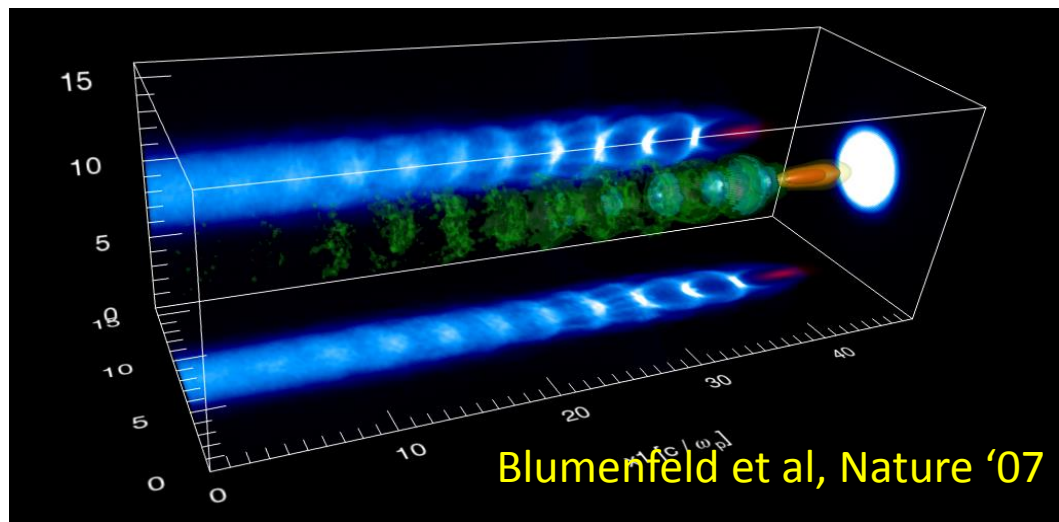
• **RF structure accelerator**

$\lambda \sim 30\text{cm}$

Plasma wakefield

$\lambda \sim 100\mu\text{m}$

0-42 GeV in 3km
42-85 GeV in 1m

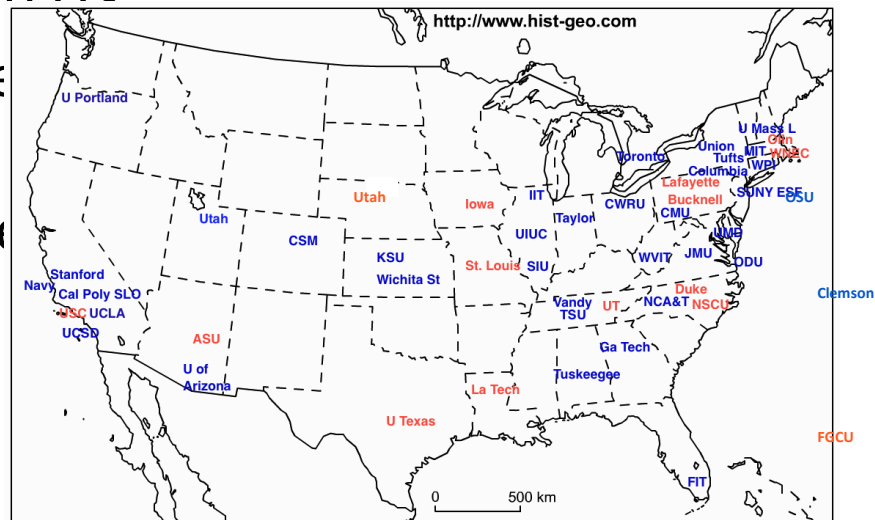


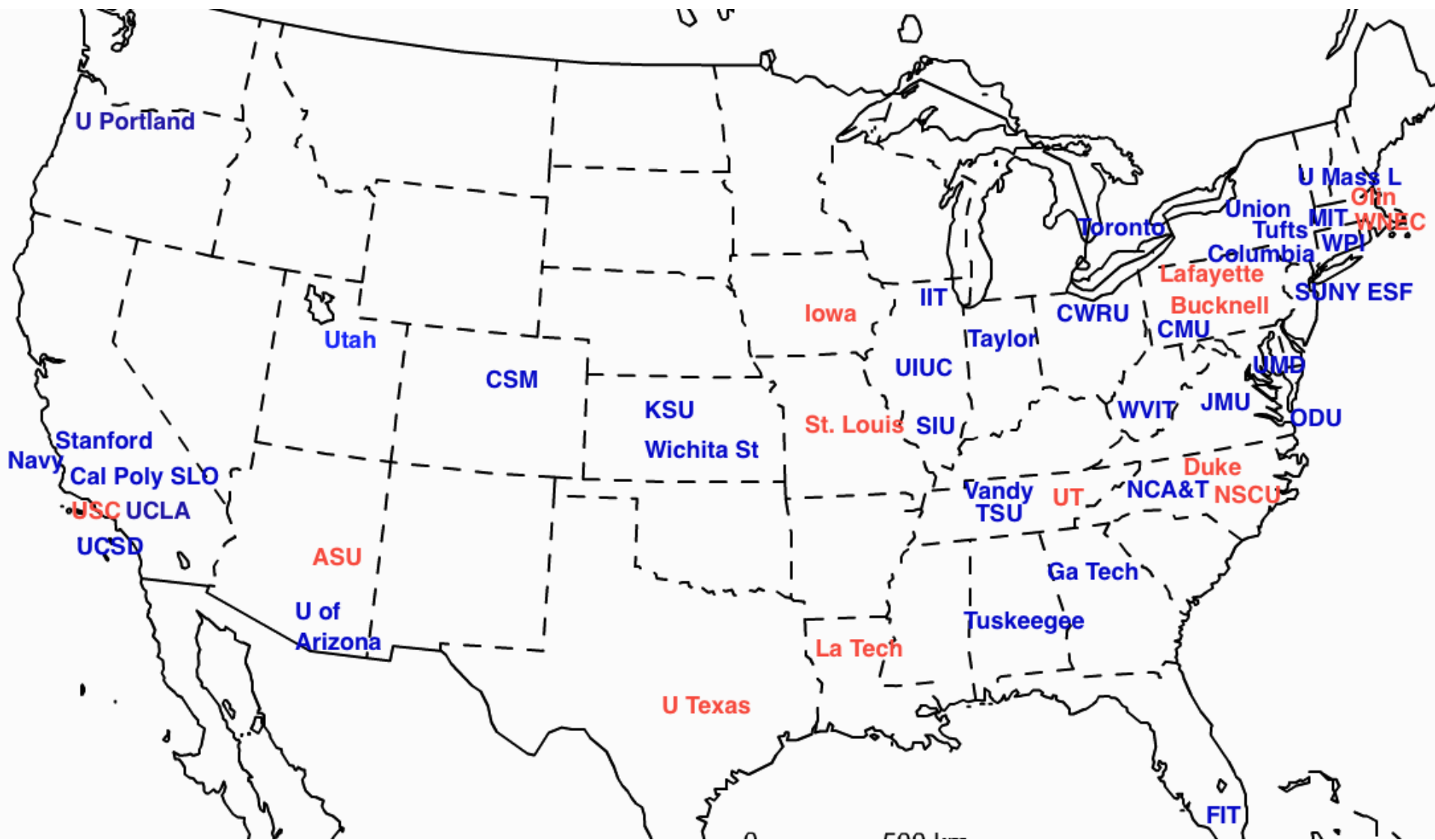
Grand Challenge Scholars Programs

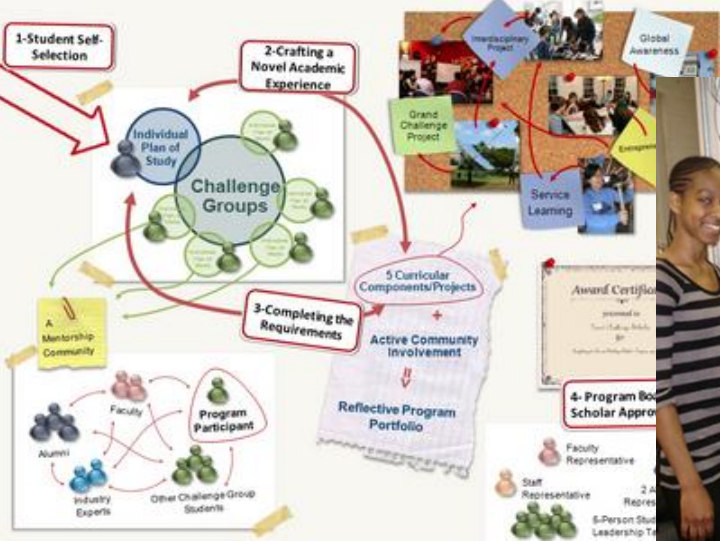
5 years out



- 115 GC Scholars graduated to-date
- 15 institutional GCSPs in the US
- 51 institutions stated interest in developing a GCSP
- National Steering Committee
 - Martha Absher, Duke
 - Lynn Stein, Olin
 - Louise Yates, USC
 - Jenna Carpenter, Louisiana Tech (Chair)
- National GCSP Workshops (Olin College 2010, AMD Campus in Austin 2011) and Panels (ASEE 2011, 2013, 2014)







Grand Challenges: More than a list...

...a call

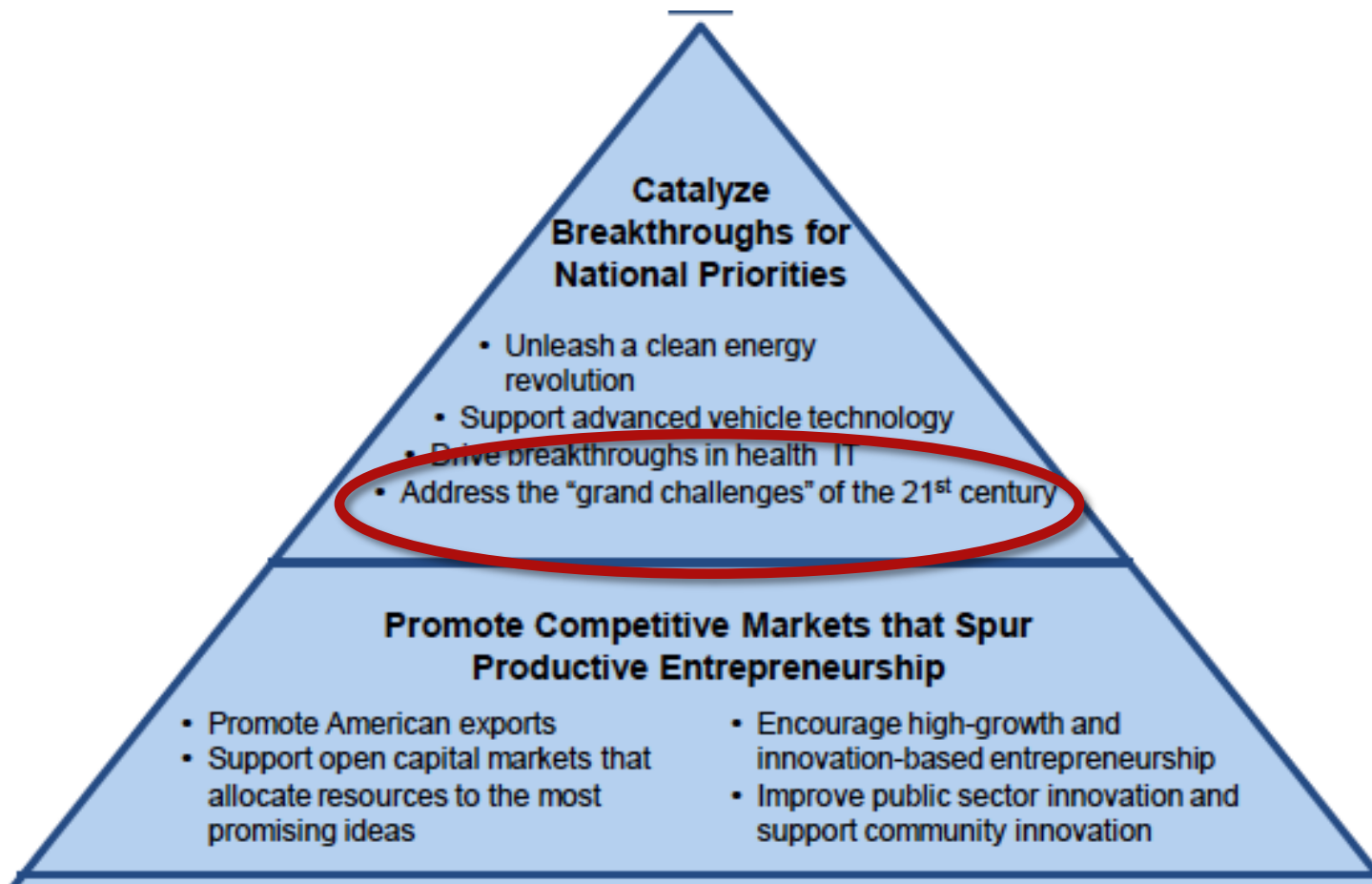
- Easily appreciated by engineers and 3rd graders (and politicians)

Response from the White House



Sept 12, 2009

A STRATEGY FOR AMERICAN INNOVATION: DRIVING TOWARDS SUSTAINABLE GROWTH AND QUALITY JOBS



Engineering and America's Future

Tom Kalil

Deputy Director, Technology and Innovation

White House Office of Science and Technology Policy

February 11, 2014: EDI Public Policy Colloquium

**“The Grand Challenge Scholars Program
Currently has 14 schools participating,
would be great to increase this number
and set a collective goal of number of
students”**

Announcing a Special Workshop

EDUCATING ENGINEERS TO MEET THE GRAND CHALLENGES

APRIL 30-MAY 1, 2014

National Academy of Engineering
in Washington, D.C.

Leaders of engineering service-learning organizations, associations, industry and academia will gather in the nation's capitol next spring for a workshop focused on how the U.S. can best prepare future engineers to meet the NAE Grand Challenges for Engineering.

The goal of the workshop is to develop a consortium of 50 universities and organizations committed to incenting students to integrate specific curricular and co-curricular experiences that prepare them to address the Grand Challenges over the course of their careers. Attendance by invitation only.

Learn more at

nae.edu/grandchallengesworkshop

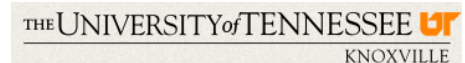
ORGANIZERS



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What we are asking you to do...



- Take the Survey by April 11:
surveygizmo.com/s3/1586877/Grand-Challenges-Workshop-Attendee-Survey
(link in March 30 email from William Kelly)
- Let me know if you would like an invitation to the April 30 workshop
- Endorse the MOU/letter to Pres. Obama when it comes to you (after May 1)
- Submit a GCSP Program proposal

Submitting a GCSP Proposal

6. Submitting a GCSP Proposal. Schools that join the GCSP Community through the GC Scholars web site will be invited to submit a proposal for an institutional program. These proposals should be concise descriptions of the following information.

1. Cover page with the name of the candidate school, name and signature of the engineering dean, name and signature of the GCSP director, and the GCSP director contact information.
2. Describe the GCSP vision for your school, noting GC-related activities.
3. Describe how GC scholars will be selected, including anticipated number of students involved.
4. Describe how the five GC curricular components will be met at your school.
5. Describe how GC scholars will be assessed and tracked at your school. Also include in this section how you will promote early student engagement in GC-related activities, as well as how you will foster intramural and extramural networking among GC scholars.

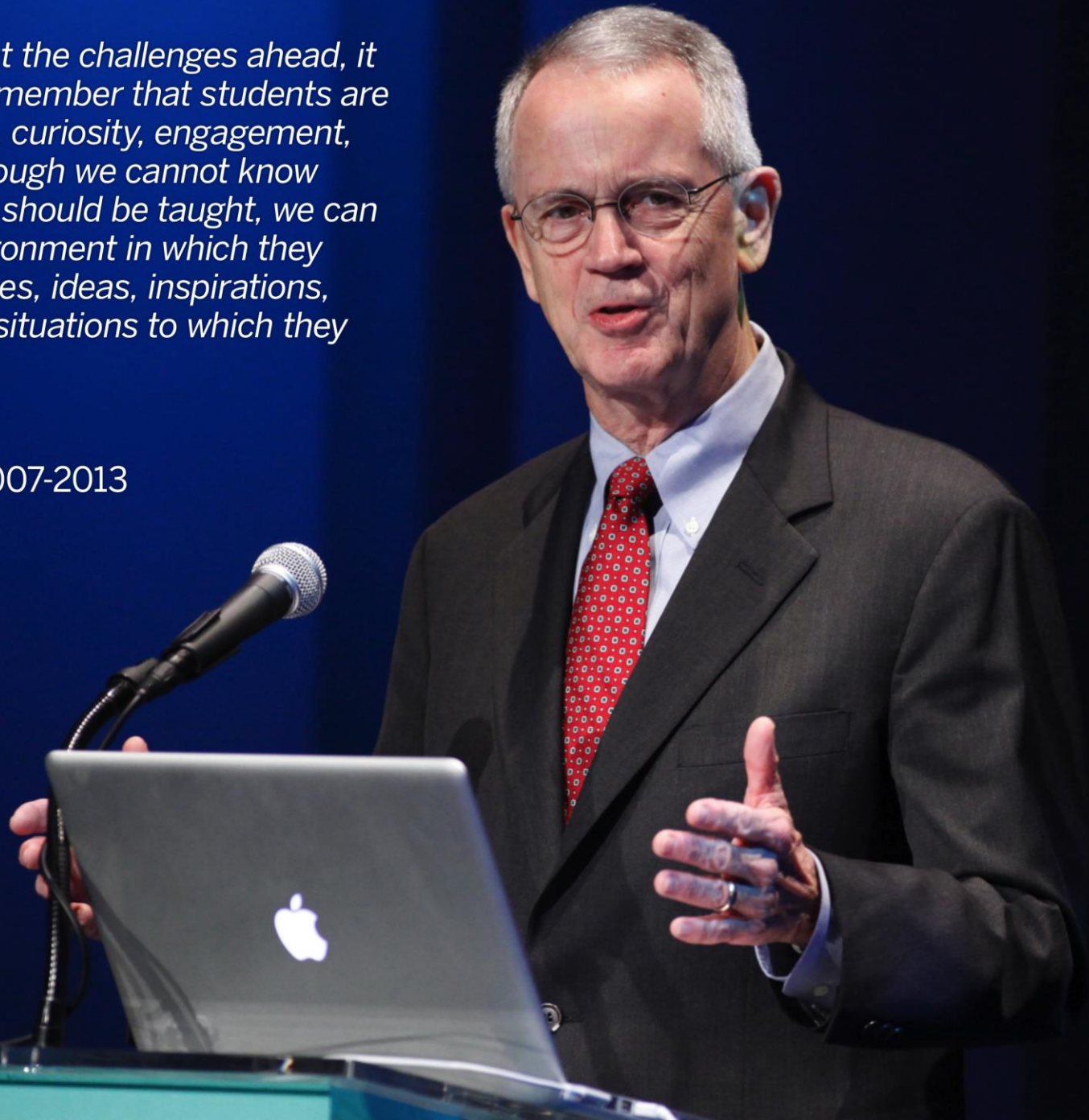
Examples of approved institutional GCSPs can be viewed at <http://www.grandchallengescholars.org/>.

Special Thanks

- Yannis Yortsos, USC
- Rick Miller, Olin
- Louis Martin-Vega, NCSU
- Tom Byers, Stanford
- Wayne Davis, UTenn
- Leah Jamieson and Bill Oakes, Purdue
- Randy Atkins, NAE
- Cathy Leslie, EWB
- +Grand Challenge Scholars partner universities:
 - ASU, LaTech, Iowa, Lafayette, Bucknell, W. NE, St. Louis, UT, Utah, Ohio St
- ASEE Bill Kelly, Jeff Goldberg, Paul Johnson

"As we think about the challenges ahead, it is important to remember that students are driven by passion, curiosity, engagement, and dreams. Although we cannot know exactly what they should be taught, we can focus on the environment in which they learn and the forces, ideas, inspirations, and empowering situations to which they are exposed."

Charles M. Vest
NAE President 2007-2013



Providing Water in Ugandan Village



Single...



...To multi

