



The NAE Grand Challenges Scholars Program



Tom Katsouleas, Dean
Duke Pratt School of Engineering

ASME Education Leadership Summit, Puerto Rico
March 14, 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



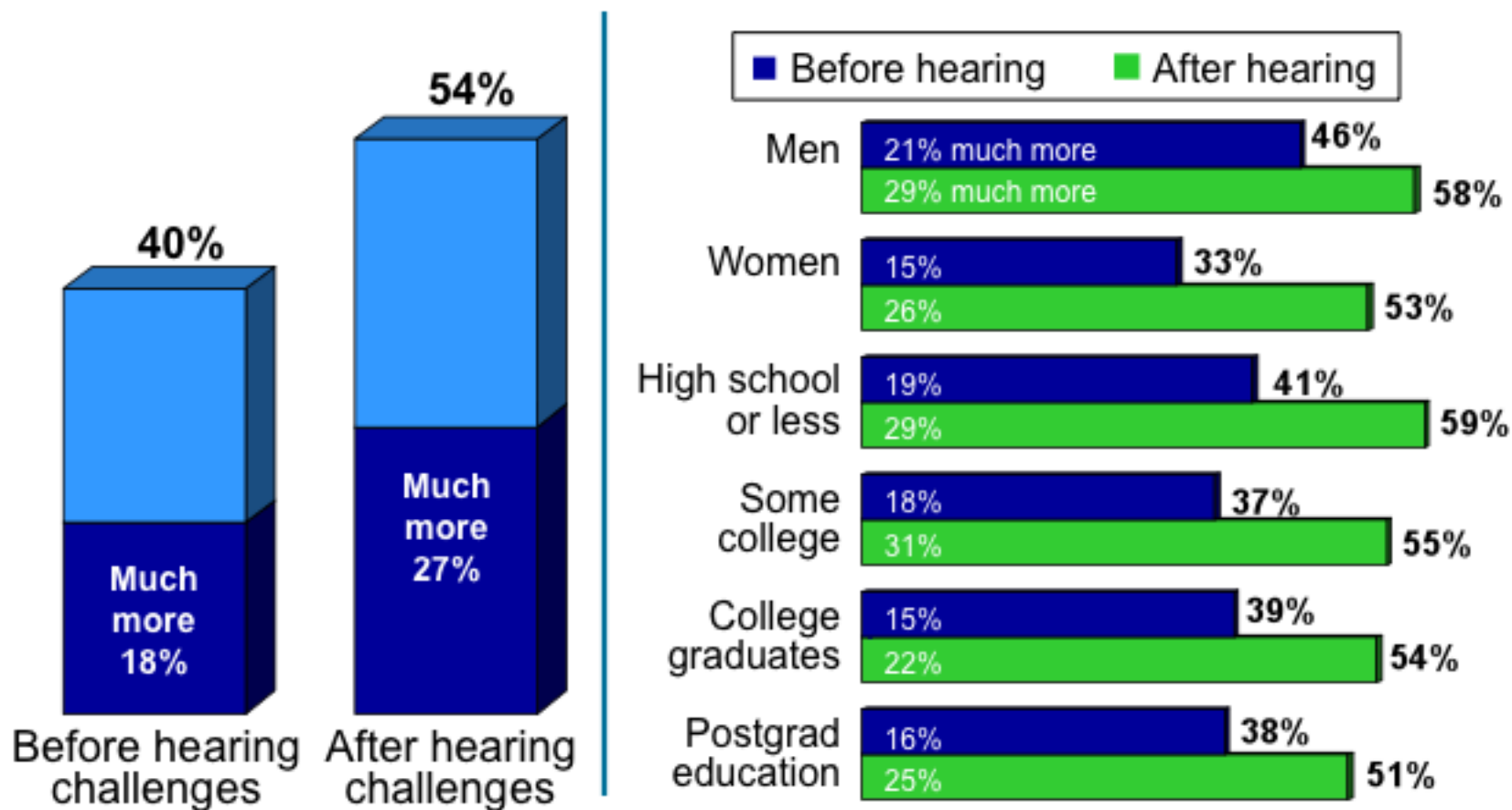
Engineer the tools of scientific discovery

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”

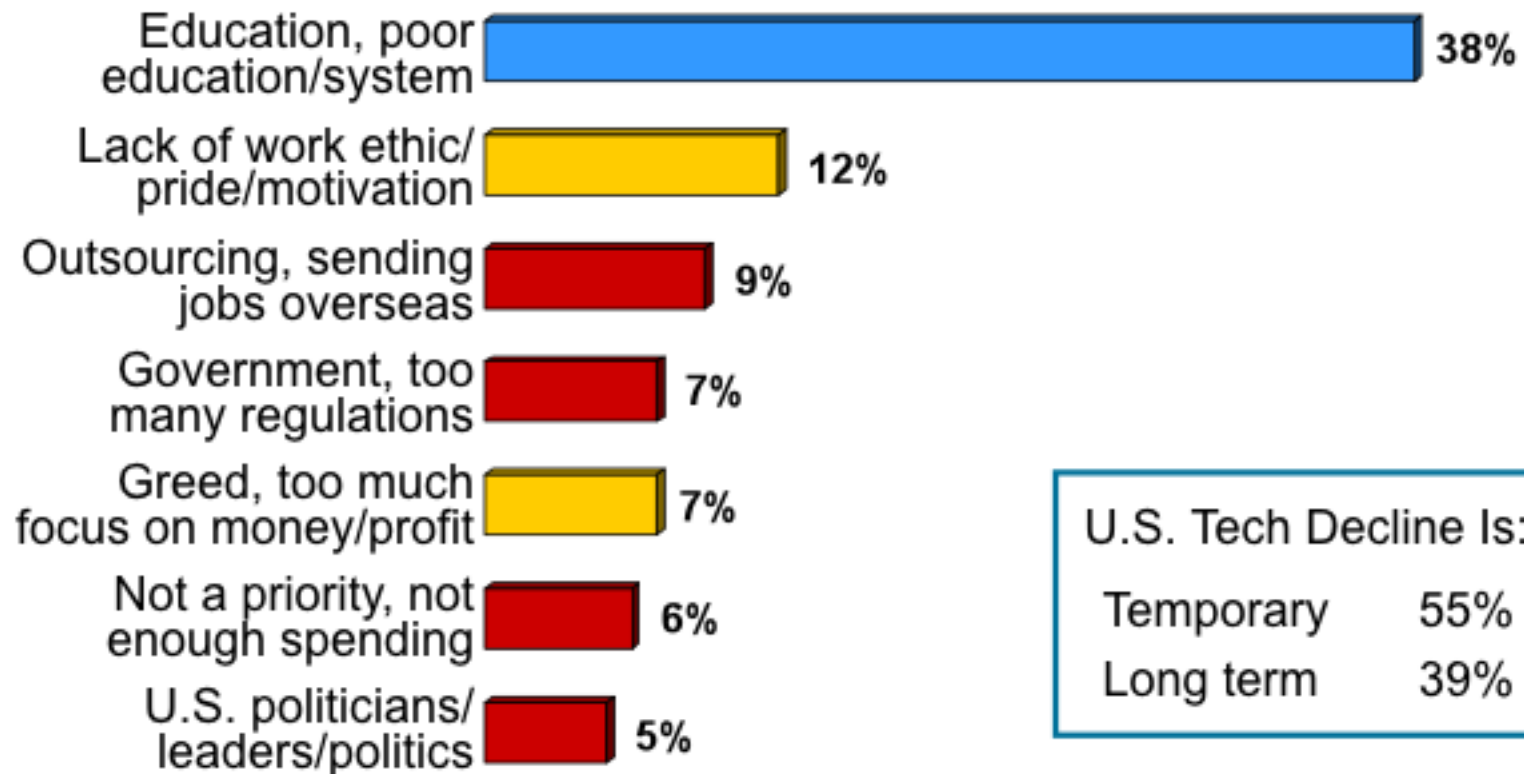
Learning about NAE challenges enhances perceptions of importance and interest in engineering.

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

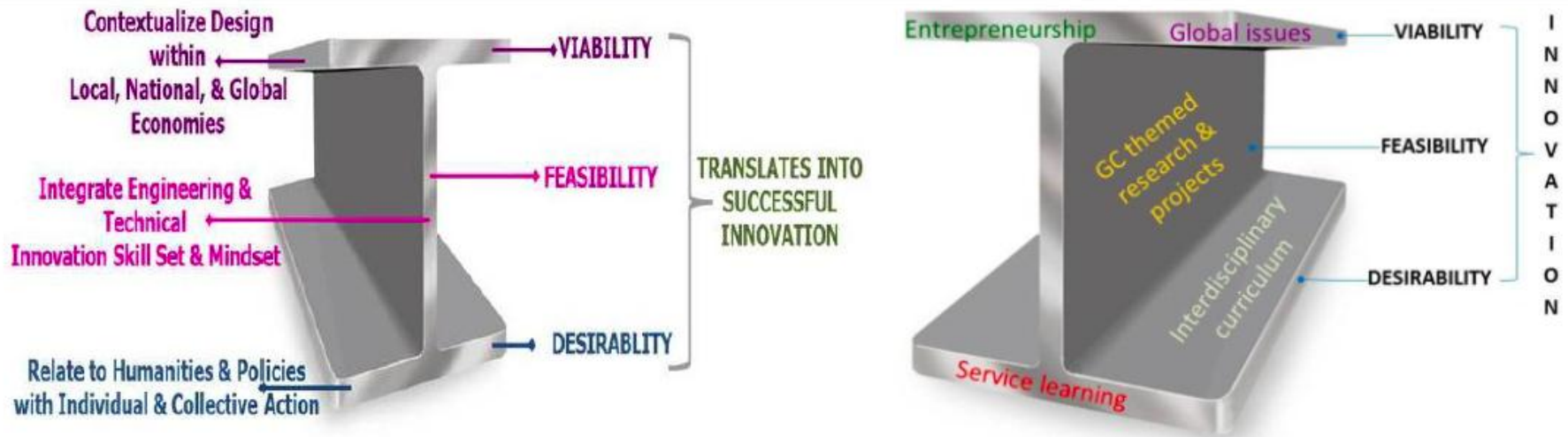


Education is the main reason given for a loss of U.S. competitiveness.

Volunteered Reasons the U.S. is Falling Behind Technologically



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

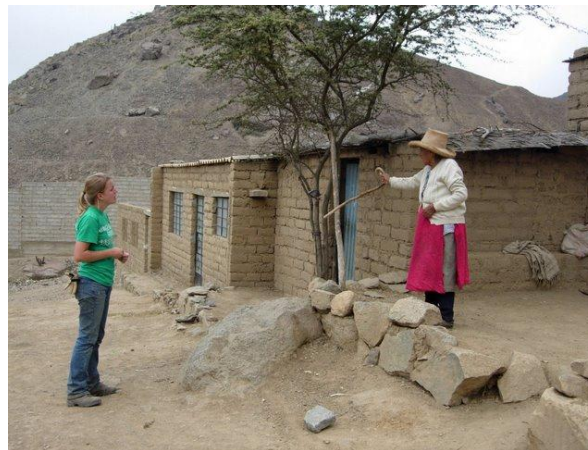
- Create a generation/community of engineers with the skillset and mindset to solve Grand Challenges
 - “The 300” of ancient Sparta → today
- Attract diverse students to engineering
- Retain “
- Incent students to stretch
- Integrate co-curricular and curricular education into a whole greater than the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



face the
challenge

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



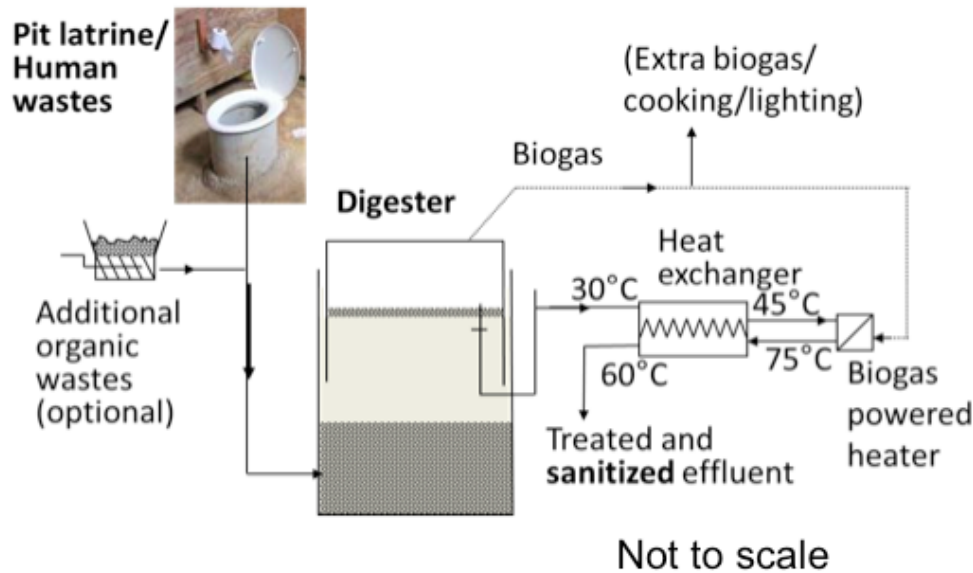
Simon GC
Scholar Maggie
Hoff working on
potable water
project in Peru

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

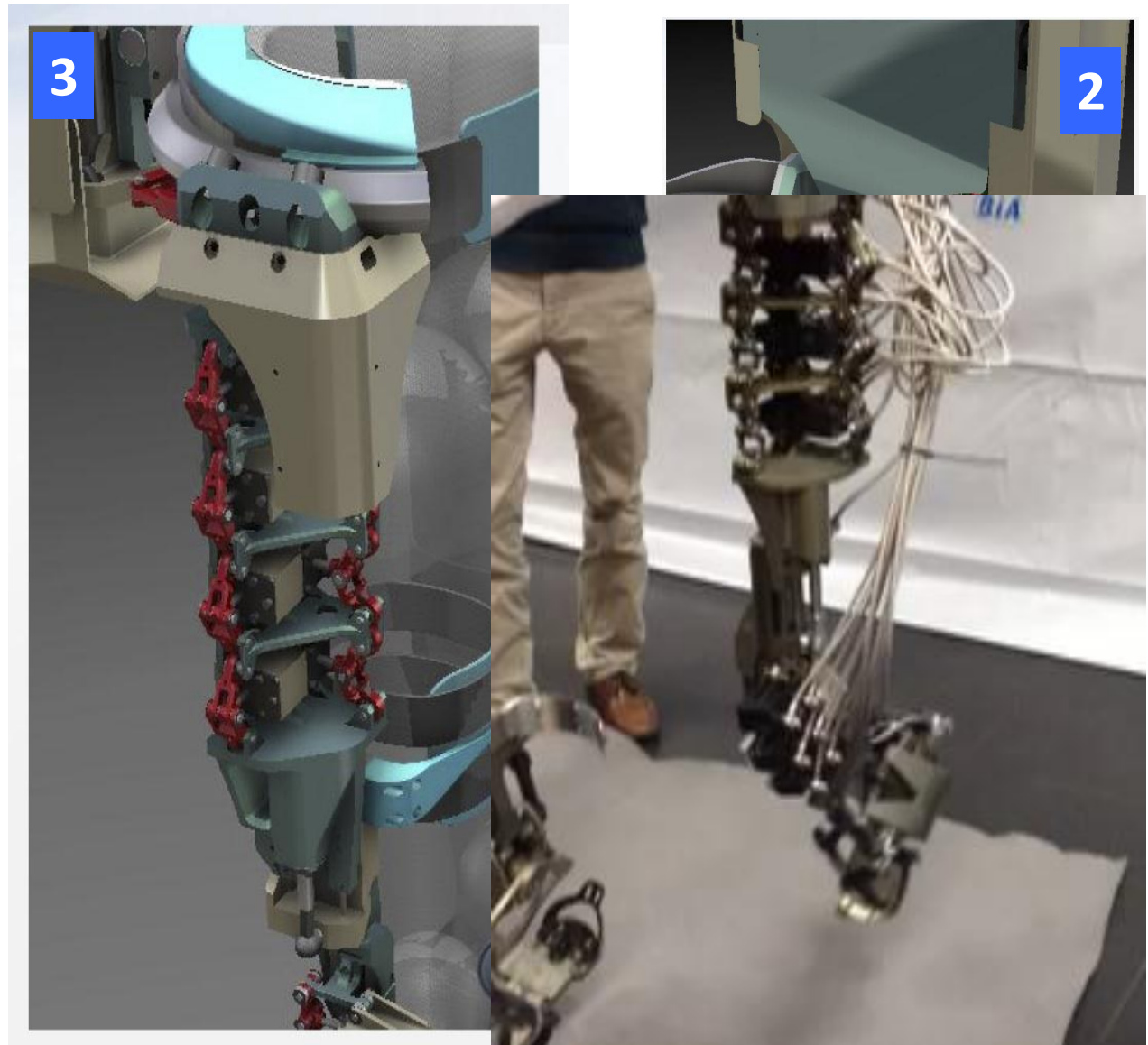
Beyond the Limits of Science

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



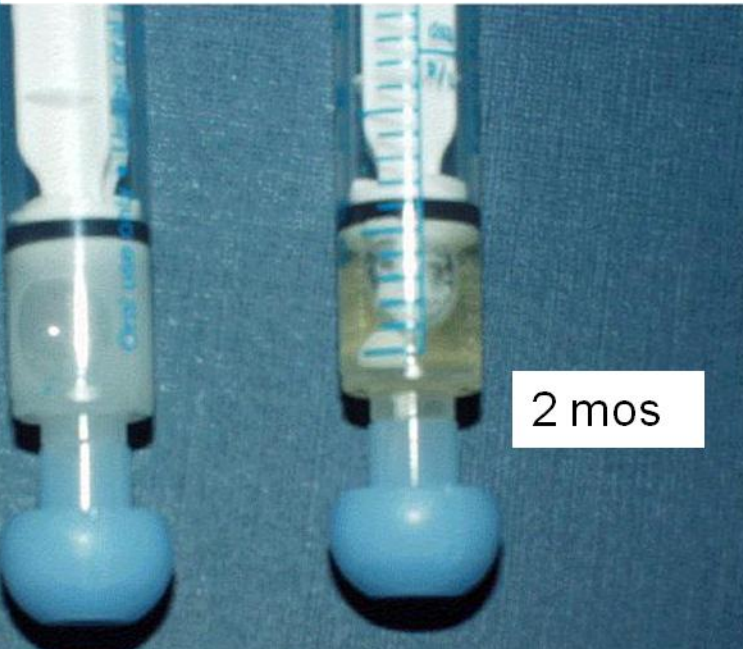
Courtesy M. Nicolelis, Du

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...

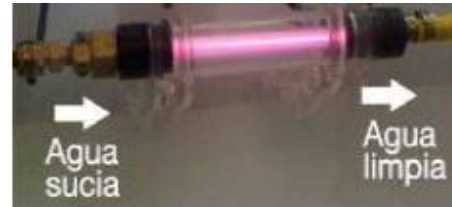
Provide Clean Water



Dean Kamen's Slingshot and Stirling generator



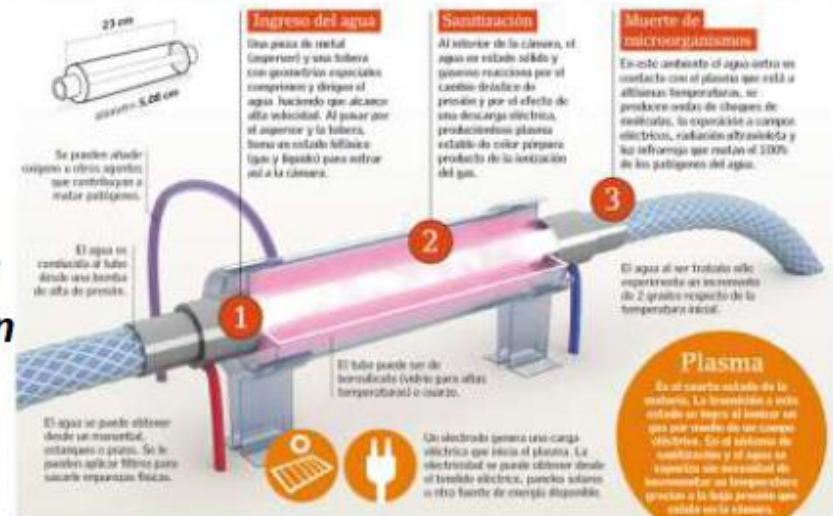
>1,000 liters/day
 <.001 cent per liter
 Less electricity than
 a hairdryer



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 o microalgas dañinos.



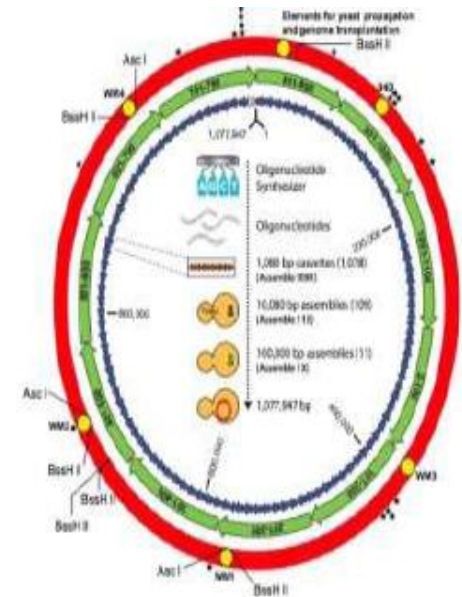
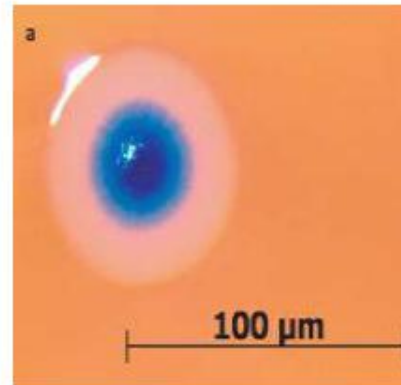
2010:

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***

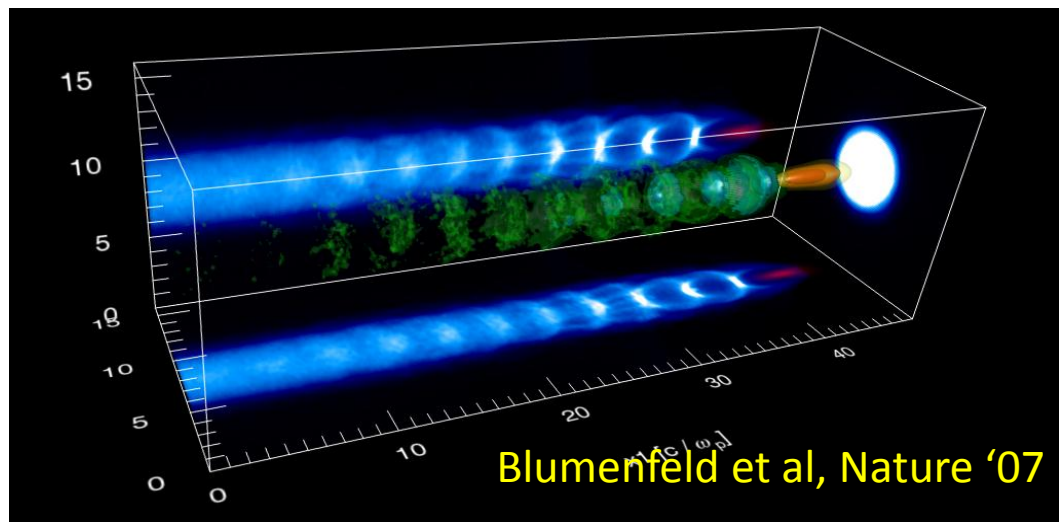
$\lambda \sim 30\text{cm}$

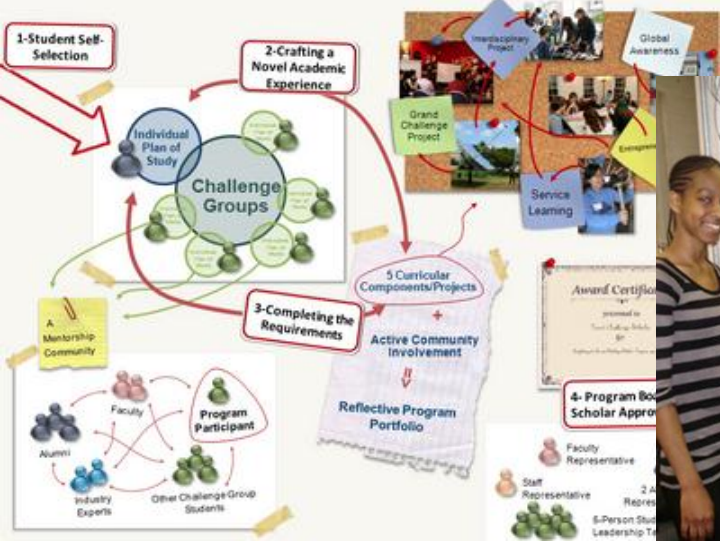
Plasma wakefield

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

0-42 GeV in 3km

42-85 GeV in 1m





Grand Challenges: More than a list...

...a call

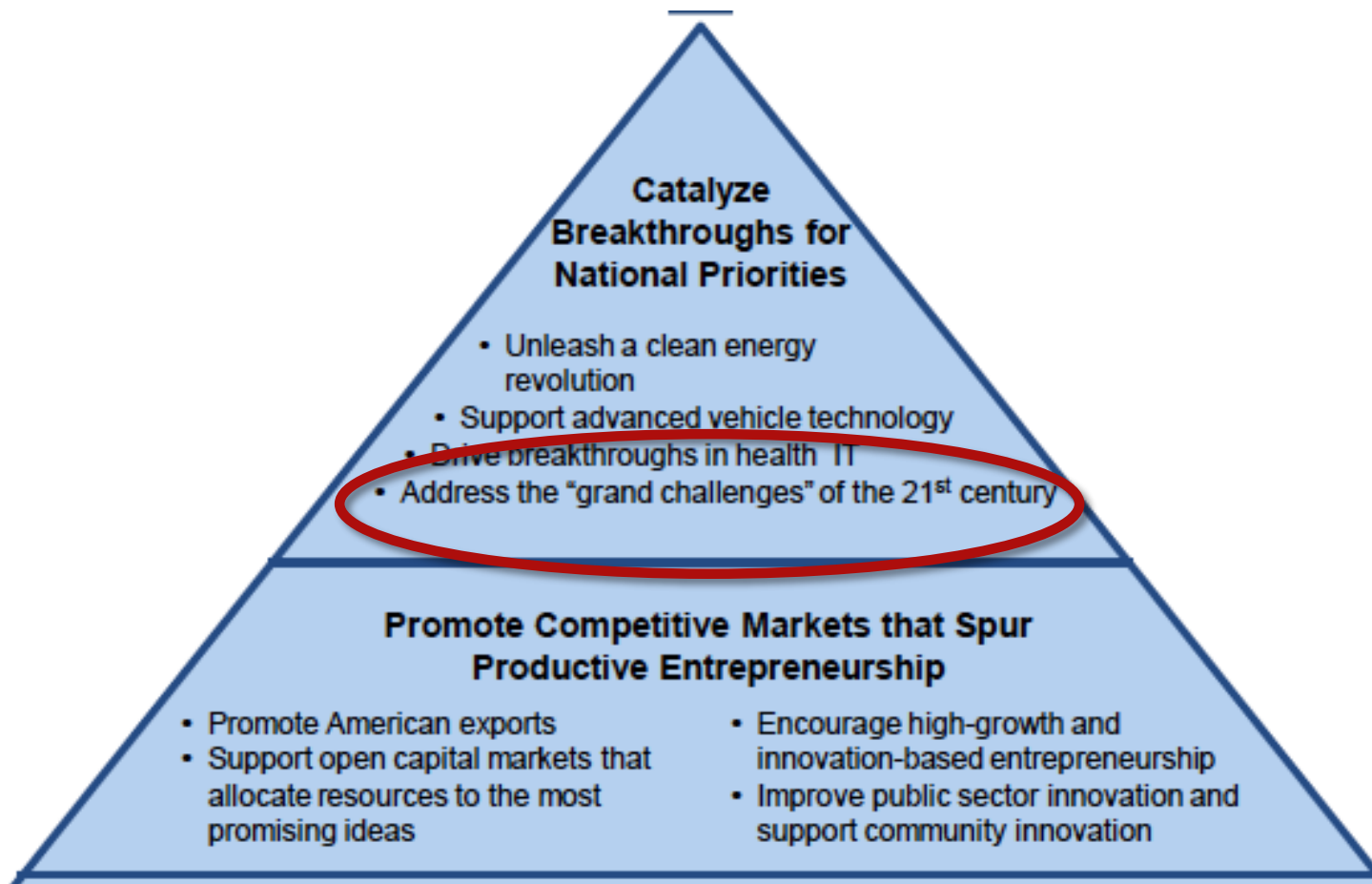
- Easily appreciated by engineers and 3rd graders (and politicians)

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

“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.



An open invitation to join...



National GCSP website:

<http://www.grandchallengescholars.org/>



National GCSP Listserv:

<https://lists.latech.edu/mailman/listinfo/grand-challenges-scholars>

- extras

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/>.

Providing Water in Ugandan Village



Single...



...To multi





"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

