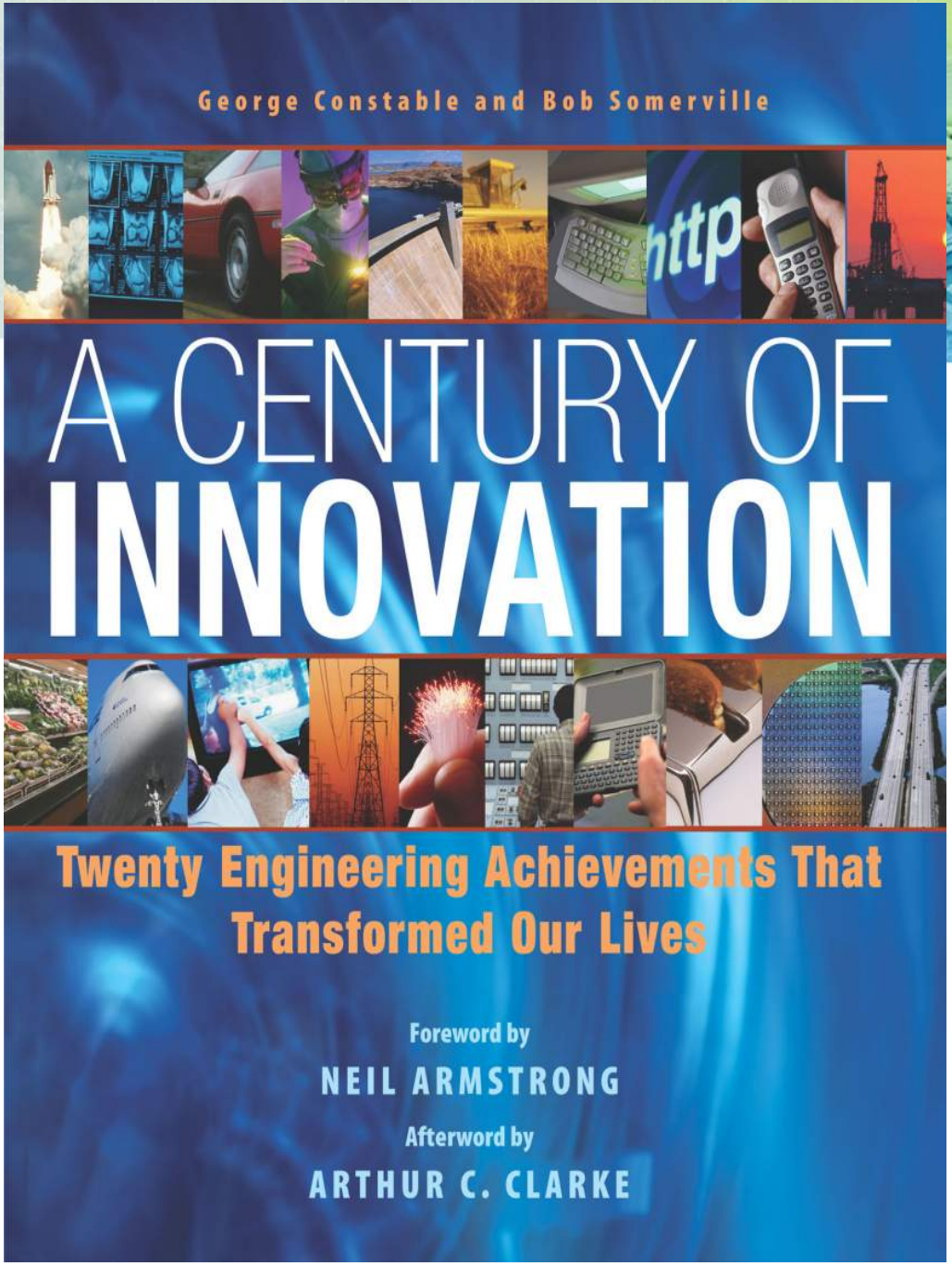
NAE GRAND CHALLENGES FOR ENGINEERING

The National Academy of Engineering


George Constable and Bob Somerville
A CENTURY OF
INNOVATION
Twenty Engineering Achievements That Transformed Our Lives
Foreword by
NEIL ARMSTRONG
Afterword by
ARTHUR C. CLARKE

Grand Challenges Committee

William Perry, *Committee Chair*
Former U.S. Secretary of Defense, U.S. Department of Defense; Professor of Engineering, Stanford University

Alec Broers
Chairman, Science and Technology Select Committee, United Kingdom House of Lords

Farouk El-Baz
Research Professor and Director, Center for Remote Sensing, Boston University

Wesley Harris
Charles Stark Draper Professor of Aeronautics and Astronautics and Associate Provost, Massachusetts Institute of Technology

Bernadine Healy
Former Director, National Institutes of Health and American Red Cross

W. Daniel Hillis
Chairman and Co-Founder, Applied Minds, Inc.

Calestous Juma
Professor of the Practice of International Development, Harvard University

Dean Kamen
Founder and President, DEKA Research and Development Corp.

Raymond Kurzweil
Chairman and Chief Executive Officer, Kurzweil Technologies, Inc.

Robert Langer
Professor of Biotechnology and Materials Science, Massachusetts Institute of Technology

Jaime Lerner
Architect and Urban Planner, Instituto Jaime Lerner

Bindu Lohani
Director General and Chief Compliance Officer, Asian Development Bank

Jane Lubchenco
U.S. Undersecretary of Commerce; Administrator of the NOAA; Professor of Marine Biology and Zoology, Oregon State University

Mario Molína
Professor of Chemistry and Biochemistry, University of California; Nobel Prize winner

Larry Page
Co-Founder and CEO, Google, Inc.

Robert Socolow
Professor of Mechanical and AerospaceEngineering, Princeton University Environmental Institute

J. Craig Venter
President, The J. Craig Venter Institute

Jackie Ying
Executive Director, Institute of Bioengineering and Nanotechnology

NAE GRAND CHALLENGES FOR ENGINEERING

NATIONAL ACADEMY OF ENGINEERING

- Advance Personalized Learning
- Enhance Virtual Reality
- Engineer Better Medicines
- Restore and Improve Urban Infrastructure
- Provide Access to Clean Water
- Manage the Nitrogen Cycle
- Develop Carbon Sequestration Methods
- Prevent Nuclear Terror
- Make Solar Energy Economical
- Reverse Engineer the Brain
- Advance Health Informatics
- Secure Cyberspace
- Provide Energy from Fusion
- Engineer the Tools of Scientific Discovery

Four Themes

Energy
Environment
Global Warming
Sustainability

Reducing Vulnerability to
Human and Natural Threats

Improve Medicine and
Healthcare Delivery

Expand and Enhance
Human Capability
And Joy

Financial Times

World News

CONFERENCE American Association for the Ad

Engineers set 'grand challenges' to enhance life

Panel suggests main goals for humanity

List designed to guide policymakers

By Clive Cookson in Boston

The world's leading engineers have proposed 14 "grand challenges" that would do the most to protect and enhance life during the 21st century. They range from engineering better medicines to making solar energy affordable.

The US National Academy of Engineering co-ordinated the international grand challenges project, using a selection panel of scientists and engineers including Craig Venter, the genomics pioneer, Ray Kurzweil, the inventor and futurist, and Larry Page, co-founder of Google. The results were released yesterday at the annual meeting of the American Association for the Advancement of Science in Boston.

The list – intended to guide policymakers and research funders – was restricted to challenges that could realistically be addressed in coming years. "Meeting these challenges would be 'game changing'," said Charles Vest, NAE president. "Success with any one of them could dramatically improve life for everyone."

The first and largest category is environmental sustainability. Two challenges relate to using the power of the sun – indirectly through nuclear fusion, which would remake on Earth the process that fuels the sun, and directly by trapping solar energy. "We only need to capture one part in 10,000 of the sunlight that falls on Earth to meet 100 per cent of our energy needs," said Mr Kurzweil. "This will become feasible with nano-engineered solar panels and nano-engineered fuel cells to store the energy in a highly decentralised manner."

Another environmental challenge is to fight global warming by capturing carbon dioxide from burning fossil fuels and storing it underground.

Much less well known than the carbon crisis is the need to avoid dangerous interference with Earth's natural nitrogen cycle. "In the process of fertilising the planet we are massively increasing the amount of biologically available nitrogen on the planet," said panel member Robert Socolow, of Princeton University. "So we are not just warming the planet, we are fertilising the planet."

In the second category, human health, there are three biomedical challenges, including discovering how the brain works – which would lead to better treatments for neurological disease and at the same time guide research into artificial intelligence.

The third category of challenges is to reduce the "vulnerability" of human society, specifically by making cyberspace secure and by developing technology to prevent nuclear terrorism.

The engineers call their fourth and final category "the joy of living".

"After you've got health and environmental sustainability and you feel protected against the bad side of both human nature and Mother Nature, there is still something else to aspire to: self-knowledge and enlightenment," said Prof Socolow.

Although the committee decided not to rank the challenges, the NAE is offering the public a chance to vote on which one they think is most important and to comment on the project. Details can be found at: www.engineeringchallenges.org

14 targets

- Make solar energy affordable
- Get energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Expand access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Make better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalised learning
- Engineer tools for scientific discovery

USA Today

common throughout our galax
Ohio State University, lead auth
day's issue of the journal *Science*.

Challenges for the 21st century identified

Coming up with ways to make solar ener
fordable, pulling carbon
viding access to
engineering cha
improve the way
and sei

tific
flu
of th

Business Week

The Grand Challenge for Science and Math

Students may resist geek studies. But they'll flock in for the opportunity to change the world

Washington Post

Release dates: February 14-20

The Mini Page®

Betty Debnam, Founding Editor and Editor at Large

Engineers Week

Making Our Lives Better

Have you ever played with building blocks, such as Legos? Have you built houses or roller coasters with a computer program?

As you were building, you might not have realized how much thinking you were doing. You were answering questions about your project, such as:

- How many rooms would your building need?
- How big could a Lego bridge be without falling down?
- How would your roller coaster gain enough energy to get up the next hill?

These are the types of questions that engineers answer every day.

Engineers Week

Feb. 15-21 is Engineers Week. Also, Thursday, Feb. 19, is Introduce a Girl to Engineering Day. With this issue about engineering, The Mini Page salutes the people who contribute so much to our daily lives.

Engineers are everywhere

Mechanical and structural engineers might be building the next highest or fastest roller coaster. They have to work within the available space in the park and make sure the design is safe.

Engineering is using imagination and technology to solve a problem. Some engineers figure out how to build things. Others invent and design ways to make existing things work better.

President Barack Obama has set some new goals for our country. Many of his administration's ideas will require the work of engineers.

The National Academy of Engineering is a group that gives the government advice about important issues in engineering. This group has named 14 engineering **challenges**, or problems, facing us in the coming years.

Let's look ahead at a few of these challenges. We'll also name some of the types of engineers who might work together on these problems. Maybe one day you'll help solve them.

• Restore and improve urban infrastructure.

Infrastructure includes water and sewer systems, roads and bridges, and electrical and natural gas **grids**.*

In many **urban** areas, or cities, these systems are in bad shape. The growing number of people in our cities has put a lot of stress on our infrastructure.

Engineers will try to find new types of construction that will last longer and work better. They'll try to build bridges and roads that include more green spaces.

- Civil engineers • Mechanical engineers
- Environmental engineers
- Structural and transportation engineers

*Grids are the wires and pipes that carry electricity and natural gas to businesses and homes.

Electrical engineers work on a civil engineering project that will help bridges be more stable during earthquakes.

Please include all of the appropriate registered trademark symbols and copyright lines in any publication of The Mini Page®.

MAKE SOLAR ENERGY ECONOMICAL

As a source of energy, nothing matches the sun. It out-powers anything that human technology could ever produce. Only a small fraction of the sun's power output strikes the Earth, but even that provides 10,000 times as much as all the commercial energy that humans use on the planet.

PROVIDE ENERGY FROM FUSION

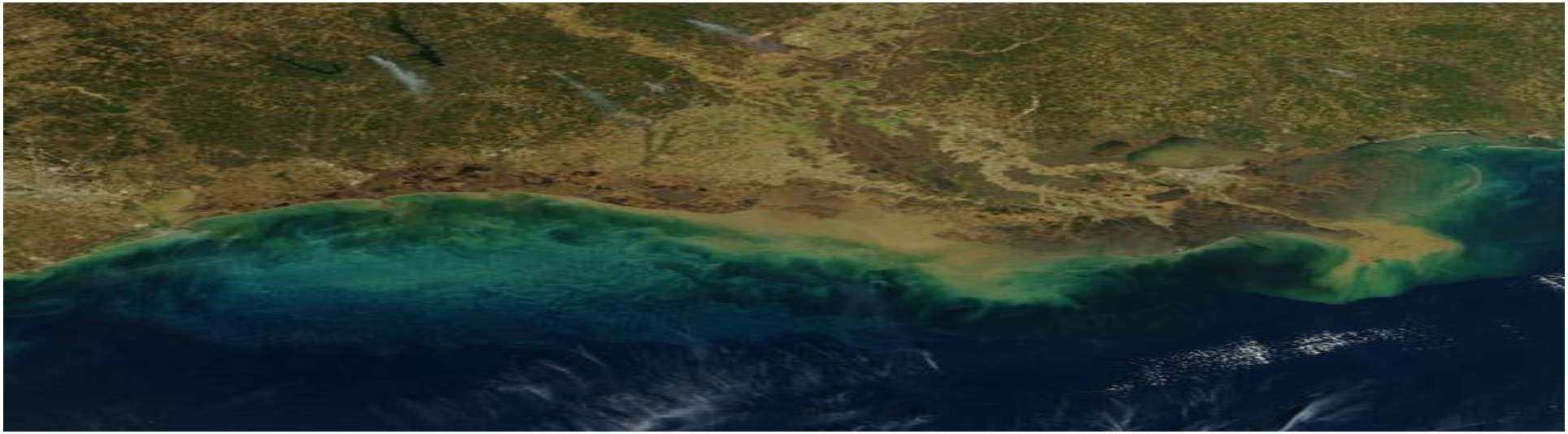
If you have a laptop computer, its battery probably contains the metallic element lithium. In theory, the lithium in that battery could supply your household electricity needs for 15 years.

Develop Carbon Sequestration Methods

The growth in emissions of carbon dioxide, implicated as a prime contributor to global warming, is a problem that can no longer be swept under the rug. But perhaps it can be buried deep under ground or beneath the ocean.

MANAGE THE NITROGEN CYCLE

It doesn't offer as catchy a label as "global warming" but human-induced changes in the global nitrogen cycle pose engineering challenges just as critical as coping with the environmental consequences of burning fossil fuels for energy.



PROVIDE ACCESS TO CLEAN WATER

When Samuel Taylor Coleridge wrote “water, water, everywhere, nor any drop to drink,” he did not have the 21st century’s global water situation in mind. But allowing for poetic license, he wasn’t far from correct.

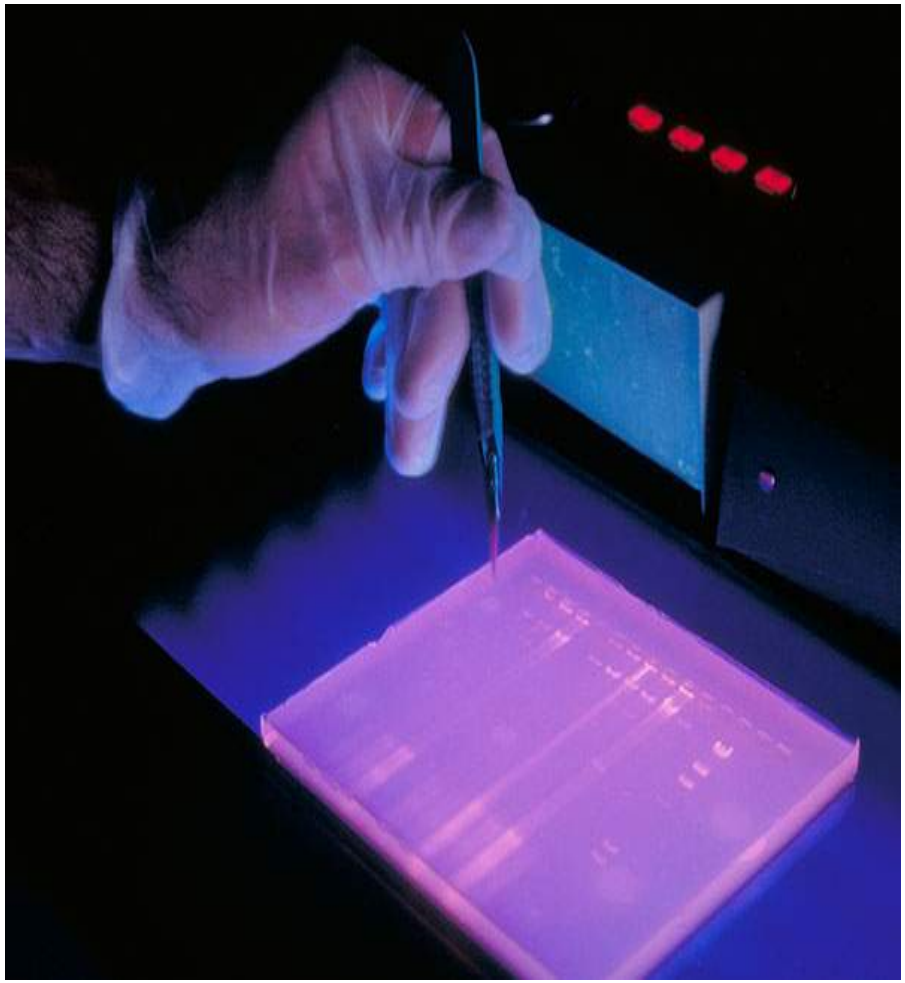
RESTORE & IMPROVE URBAN INFRASTRUCTURE

In 2009, the American Society of Civil Engineers issued a report card, grading various categories of U.S. Infrastructure. The average grade was a “D.”

ADVANCE HEALTH INFORMATICS

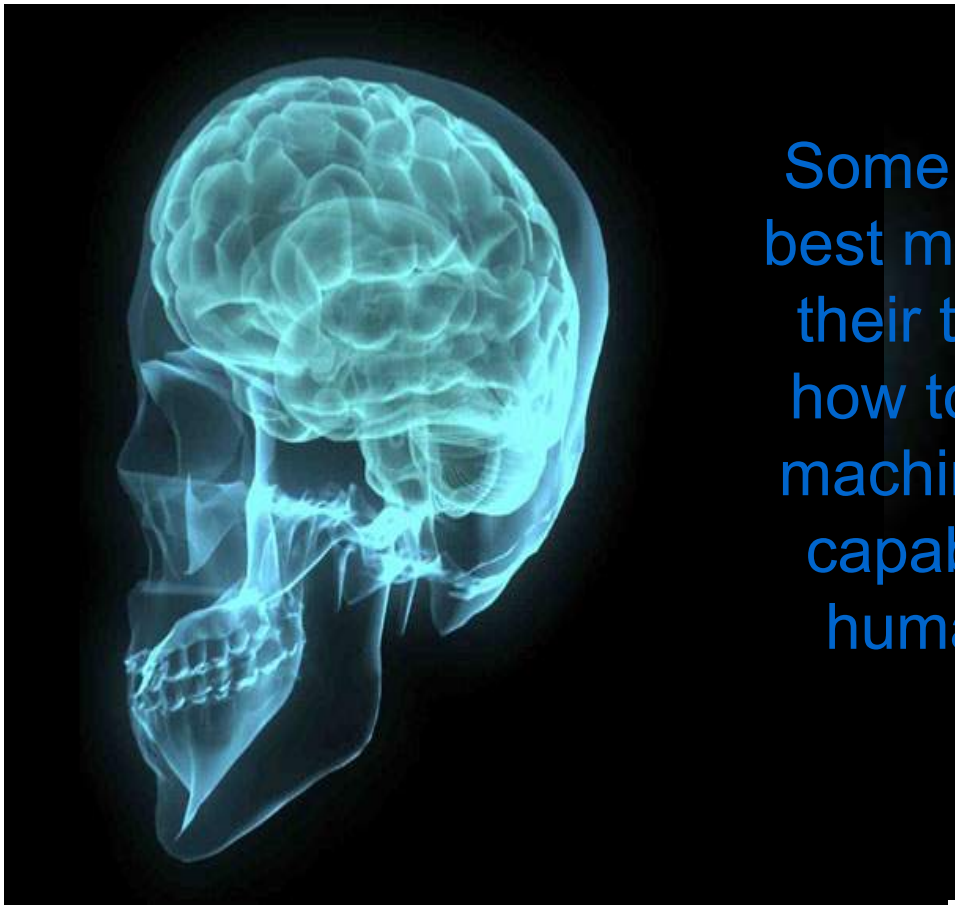
When you dial 911 for a medical emergency, the outcome may very well depend on the 411 – the quality of the information available about your condition and ways to treat it.

ENGINEER BETTER MEDICINES



Doctors have long known that people differ in susceptibility to disease and response to medicines. But, with little guidance for understanding and adjusting to individual differences, treatments developed have generally been standardized for the many rather than the few.

Reverse Engineer the Brain



Some of engineering's best minds are focusing their thinking skills on how to create thinking machines – computers capable of emulating human intelligence.

PREVENT NUCLEAR TERROR

Long before 2001, defenders of national security worried about the possible immediate death of 300,000 people and the loss of thousands of square miles of land to productive use through an act of terror.

SECURE CYBERSPACE

Personal privacy and national security in the 21st century both depend on protecting a set of systems that didn't even exist until late in the 20th – the electronic web of information – sharing known as cyberspace.

ENHANCE VIRTUAL REALITY

To most people, virtual reality consists mainly of clever illusions for enhancing computer games or thickening the plot of science fiction films. But in addition to its growing use in various forms of entertainment, virtual reality is becoming a powerful new tool within many specialized fields, from psychiatry from psychiatry to education.

ADVANCE PERSONALIZED LEARNING

For years, researchers have debated whether phonics or whole-word recognition is the best way to teach children how to read. As an astute first-grade teacher, though, and the answer is likely to be that it depends on the kid.

ENGINEER THE TOOLS OF SCIENTIFIC DISCOVERY

Scientists explore, experiment, and discover; engineers create, design and build. But they are partners in the great quest for understanding many unanswered mysteries of nature.


global grand
challenges
summit
ter Energy Nexus
hts,
Genentech
A Member of the Roche Group
global grand
challenges
summit


ROYAL ACADEMY OF ENGINEERING
Tackling Global Challenges and Creating a Better Future
应对全球挑战，创造美好未来
The 2nd Global Grand Challenges Summit
第二届全球重大挑战论坛
September 15-16, 2015 | 2015年9月15日-16日
Beijing·China | 中国·北京

FIRST Global

Grand Challenges Scholars Program

- Combined curricular and extra-curricular program designed to prepare students to solve the Grand Challenges facing society.
- Currently taking place at more than 70 colleges/universities across U.S.
- Students can get degree with focus on one of the Grand Challenges
- **5 components of GCSP curriculum:**
  - Research experience
  - Interdisciplinary curriculum (Engineering+)
  - Entrepreneurship.
  - Global dimension
  - Service learning

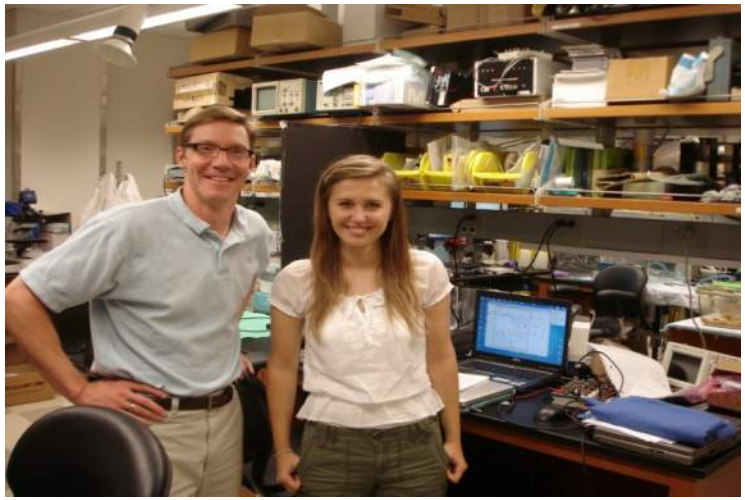
NAE GRAND CHALLENGES SCHOLARS PROGRAM

Students at Work!

Water Improvement in Uganda

System Approach to Electrofuel Production

Cancer Imaging Methodology



Reverse-Engineering the Brain

the WHITE HOUSE

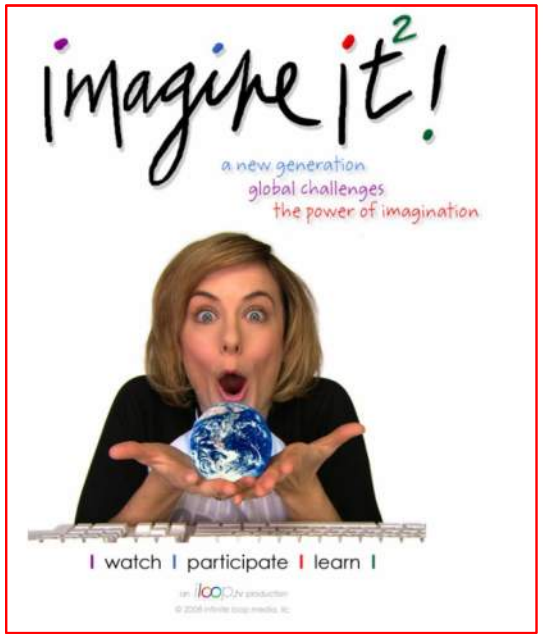
PRESIDENT OBAMA IS CALLING ON THE SCIENCE COMMUNITY
TO JOIN HIM IN PURSUING A GRAND CHALLENGE

BRAIN INITIATIVE

BRAIN RESEARCH
THROUGH ADVANCING
INNOVATIVE
NEUROTECHNOLOGIES

High School in North Carolina frames its *entire* curriculum on the NAE Grand Challenges for Engineering

Movie



K-12 Education

Drexel University STEM GK-12:
Catalyzing STEM Education via the NAE Engineering Grand Challenges

Competition

JETS EXPLORE... ASSESS... EXPERIENCE ENGINEERING

1420 King Street, Suite 405 • Alexandria, VA 22314 • Phone: 703.548.5387 • Fax: 703.548.0769 • E-mail: info@jets.org

FOR IMMEDIATE RELEASE
August 26, 2009

Contact: Leann Yoder
JETS
(703) 548-5387 / lyoder@jets.org

NATIONAL ACADEMY OF ENGINEERING GRAND CHALLENGE CHOSEN AS THE THEME FOR JETS HIGH SCHOOL COMPETITION

TEAMS Asks Students to Tackle the Global Crisis of Providing Access to Clean Water

WASHINGTON, DC, August 26, 2009 – With the theme, "Water, Water, Everywhere" the Junior Engineering Technical Society (JETS) launches its annual TEAMS competition for high school students throughout the country.

The theme-based engineering competition provides students in grades nine through 12 with the opportunity to make real-world connections between math and science to actual engineering challenges. With the release of the National Academy of Engineering's (NAE) Grand Challenges for Engineering, the emphasis on providing access to clean water became the main focus for the competition.

In 2007 the NAE assembled some of this generation's most accomplished technological thinkers and asked them to identify the top engineering challenges for improving the way we live. After a year-long study that included public input from around the world, the panel announced 14 challenges on the project website http://www.engineeringchallenges.org. They fell into in four broad themes that are essential for humanity to flourish: sustainability, health, reducing vulnerability, and joy of living.

Engineering Photo Competition: The Grand Challenges of Engineering

The College of Engineering is now accepting submissions for its "Grand Challenges of Engineering" photo competition. Participation is open to all Drexel students, faculty and staff. Five to 10 photos should be submitted that relate to the grand challenges of engineering. Submissions are due by 5 p.m. today, May 28, 2010 at the Center for Automated Technology room 170 (3101 Ludlow Street) or by email to Chris Hennessy at co-op@coe.drexel.edu.
The first-place winner will receive $500. Second-and third-place winners will receive $200 and $100, respectively.
For rules and other information, visit http://drexel.edu/coe/news/events/engphotocontest/ or contact Hennessy at co-op@coe.drexel.edu.

MARVEL

IRON MAN 3

INVENTOR and INNOVATOR FAIR

Presented by

BROADCOM. FOUNDATION

VISA

DISCOVERY SCIENCE CENTER


OCTOBER 23-24 // NATIONAL MALL, DC
10AM – 5:30PM, BOOTH 102
USA SCIENCE AND ENGINEERING FESTIVAL EXPO
TURNING DREAMS INTO REALITY
TRON
LEGACY
PHOTO CREDIT

Picture from *Washington Post*

Company
- Company
- About NI
- NI Shared Value
- Company Programs
- Investor Relations
- Newsroom
- Careers
- Supplier Information
- Worldwide Offices

Grand Challenges for Engineering

Throughout history, engineering has driven the advance of civilization. As populations grow and our needs and desires expand, sustaining civilization's continuing advancement while still improving the quality of life becomes more challenging. In each of the b categories defined by the National Academy of Engineering—sustainability, health, security, and joy of living—many of our most important grand challenges await engineering solutions. National Instruments empowers its customers to create systems that impr the world and address these challenges of today, as well as those yet to come.

Sustainability

Today's engineers must determine methods for sustaining resources such as clean water anc energy, as well as maintaining and improving infrastructure to support civilization. NI custome address these challenges worldwide every day, from developing novel and more economical system configurations to creating innovative solutions for monitoring the health of our infrastructures to ensure safety or preserve historic buildings.

Learn more

Health

Anyone who goes to the doctor or takes a medication benefits from the work of engineers. The unique combination of basic biomedical science paired with engineering and physical scienc necessary to create powerful tools and techniques that address pressing medical problems. N customers expand the scope of the world's medical knowledge and capabilities using advanc platform technology to research new treatment types for diabetes, test drug quality, and imple a revolutionary cancer treatment.

Learn more

Security

The need for technologies that protect society from a variety of threats, from nuclear attacks or accidents to massive security breaches in cyber space, is growing. Using NI technology, companies are building robotic systems to handle jobs that are unsafe for humans, such as nuclear decommissioning and explosive detection. Additionally, NI customers are building applications to analyze and help secure the radio spectrum by providing technology to develc spectral monitoring and signal intelligence systems.

Learn more


BECAUSE DREAMS NEED DOING
www.engineeringchallenges.org