

Remembering George Crabtree



George was a distinguished materials physicist

- Ph.D. degree from University of Illinois at Chicago, 1974 and joined Argonne National Laboratory the same year
- He was a PI beginning in 1974 under the Atomic Energy Commission Division of Physical Research --- which eventually became BES
- Professor of physics at Northern Illinois University (1990 to 2003) and at the University of Illinois at Chicago (2010-2023)
- Over 440 publications; h-index of 80; most cited papers are on magnetic properties of high T_c superconductors, especially vortex motion
- Many honors including National Academy of Sciences (2008) and Kamerlingh-Onnes Prize (2003) for his work on the physics of vortices in high-temperature superconductors

George was an important leader and manager of research

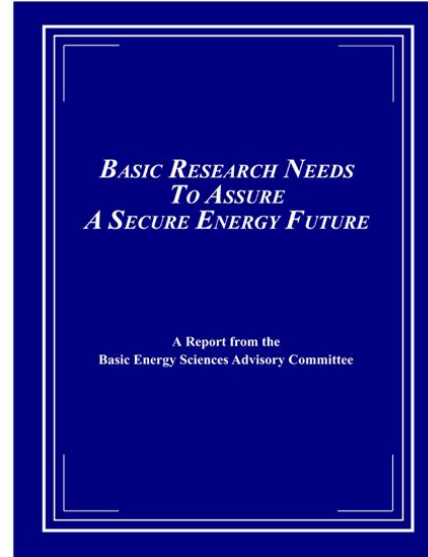
- In 2010, DOE launched the Energy Innovation Hubs across the Department
 - ❖ Modeled on the proactive approach to science management exemplified by the Manhattan Project and AT&T's legendary Bell Laboratories
 - ❖ Integrated, multidisciplinary research centers that combine basic and/or applied research with engineering to accelerate scientific discovery and address critical energy issues
 - ❖ **"Dream teams" of researchers...** with strong leadership, providing a centroid for research in the fields that they represented
 - ❖ Initial topics: Nuclear energy, Solar Fuels, and Buildings Efficiency
- In 2012, BES released the request for proposals for a Batteries and Energy Storage Hub
- The successful team, the Joint Center for Energy Storage Research, was led by ANL with Director George Crabtree.
- JCESR completes its 10th and final year in 2023

George was a leader of BES strategic planning

- In 2002 BES began a new approach to planning for priority research directions to address significant challenges for improved and innovative energy technologies
- The now-standard Basic Research Needs workshop approach:
 - ❖ Workshop chair/co-chair from the community experts plus panel leads for specific, small group, discussions
 - ❖ 3-day workshop ~100 participants with plenary talks, small group discussions, reconvening for updates during the activities, resulting in a consensus view of priority research directions for basic research
 - ❖ Provide community resources on BES webpages: a pre-workshop document summarizing the factual status of the field and a post-workshop report on the priority research directions and summaries of the discussions supporting these.
 - ❖ Subsequent reference to the reports and research directions in funding opportunities.

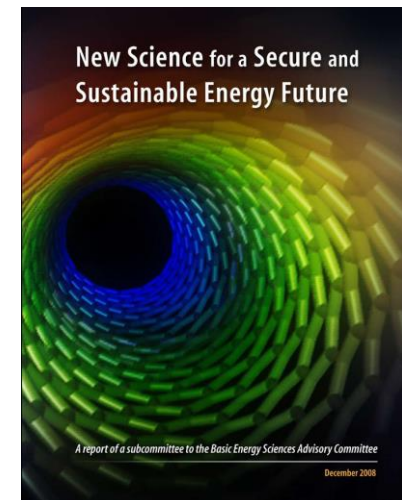
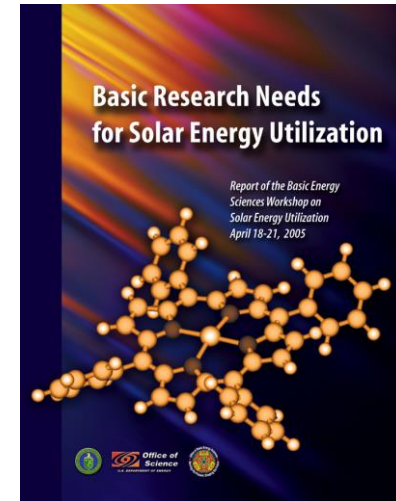
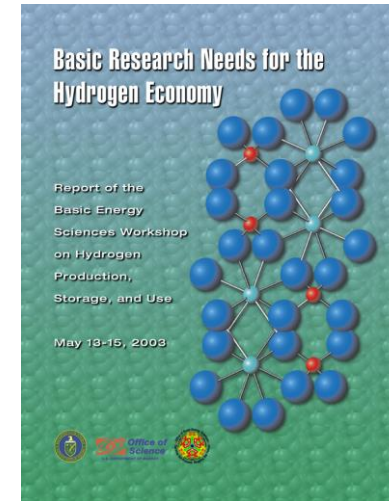
The first BRN Report 2003

- Overall report co-chaired by Linda Horton
- Workshops in a wide variety of energy topics
- George chaired the workshop on “Renewable and Solar Energy”



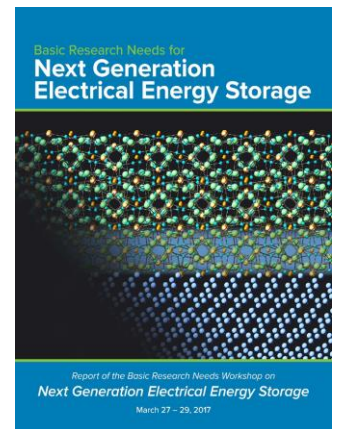
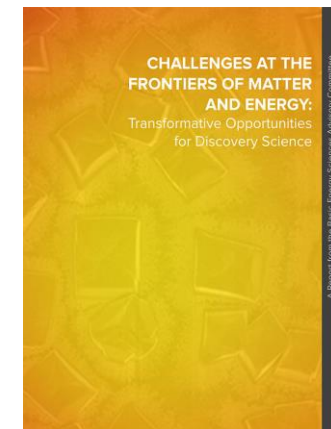
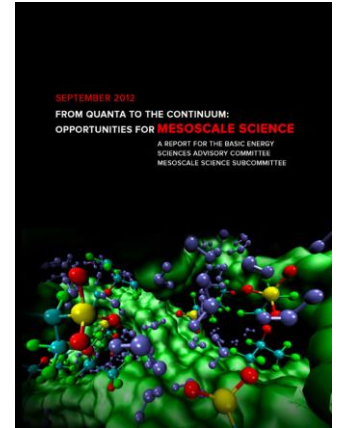
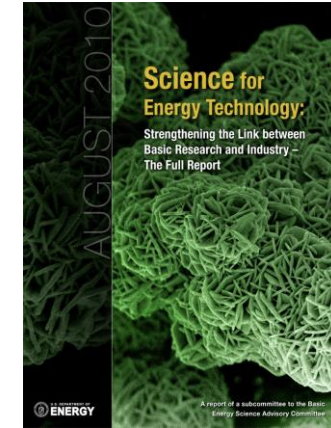
George led many workshops and reports

- 2003: Hydrogen Economy (led to Physics Today article by George, Millie Dresselhaus and Michelle Buchanan)
- 2005: Solar Energy Utilization
- 2008: New Science for a Secure and Sustainable Energy Future – Assessment of the preceding 12 BRN workshops. Recommendations provided foundations for the BES Energy Frontier Research Centers, DOE Energy Innovation Hubs, and SC Early Career programs
 - ❖ It will take “**dream teams**” of highly educated talent, equipped with forefront tools, and focused on the most pressing challenges to increase the rate of discovery.
 - ❖ U.S. leadership requires BES to lead a national effort to aggressively recruit the best talent through a series of workforce development and **early career programs** aimed at inspiring today’s students and young researchers to be the discoverers, inventors, and innovators of tomorrow’s energy solutions.

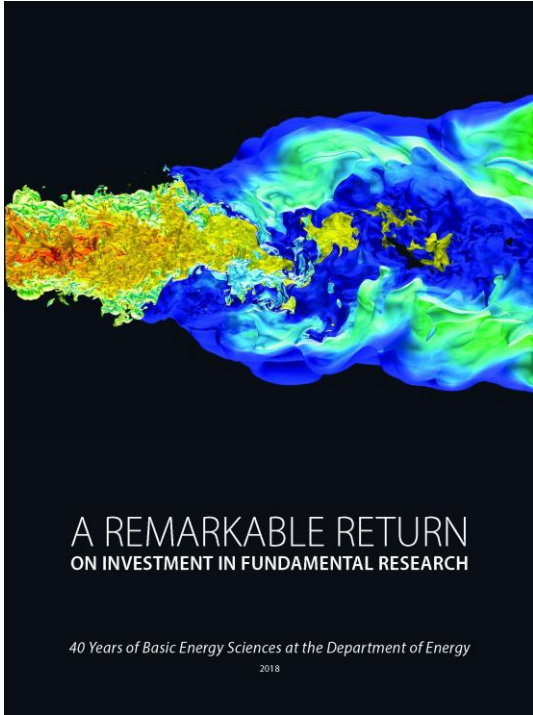


And more...

- 2010: Science for Energy Technologies: Strengthening the Link between Basic Research and Industry
- 2012: From Quanta to the Continuum: Opportunities for Mesoscale Science
- 2015: Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science
- 2017: Next Generation Energy Storage



Last but not least...



LEVERAGING SEMICONDUCTOR SCIENCE FOR CLEAN ENERGY TECHNOLOGIES

Keeping the lights on in the United States consumes 300 billion kilowatt hours of electricity annually. Most of that light still comes from incandescent bulbs, which haven't changed much since Thomas Edison invented them 140 years ago. But now a dramatically more efficient lighting technology is coming on-line: semiconductor devices known as light-emitting diodes (LEDs) use 85 percent less energy than incandescent bulbs, last 25 times as long, and have the potential to save U.S. consumers a huge portion of the electricity now used for lighting.

How we generate electricity is also changing. The units of solar cells that convert light from the sun into electricity have come down dramatically over the past decade. As a result, solar power installations have grown quickly, and in 2016 accounted for a significant share of all the new electrical

High-purity silicon is produced in Arizona. Credit: © iStockphoto.com/Photo by Scott G. Smith. All rights reserved. The background image shows the solar panels for the first time in the world.

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TOUGH STUFF EXTREME MATERIALS FOR EXTREME CHALLENGES

If you're going to make bombs, and you want them to perform predictably and reliably, then you want to know how the materials they are made of behave under extreme conditions. Metals such as steel or aluminum or platinum are not uniform throughout. They have microscopic "grains" which are the metal grains are connected at the microscopic level. And it is this microstructure that determines their behavior—how they behave in an airplane or an automobile collision, how they fail at high temperatures. The microstructure, in turn, is influenced both by the composition of the material, by how it is processed or formed into useful parts, and by how the material ages.

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Transforming THE CHEMICAL INDUSTRY

There are huge reserves of oil in the deep waters of the Gulf of Mexico. Retrieving that oil is difficult because of very substantial challenges, but today a major oil company is poised to lower a string of pipes 7,000 feet down to the bottom of the Gulf to start pumping that oil, which comes out of the well at very high temperatures. The steel pipe is coated with a unique insulating layer, a type of plastic with remarkable properties: it can safely cope with oil at temperatures as high as 300°F while surrounded by water at temperatures close to freezing. The insulating plastic also protects the outside of the pipe from the corrosive effects of the seawater.

The specialized polymer is made from chains of organic carbon-based molecules that do not react in water. Rather than be synthesized by a powerful chemical process, which in addition to specialized plants has also found application in the food industry, in the pharmaceutical industry and in agricultural chemicals, and even in novel bio-products that transform natural products such as pigments into chemicals and fuels. The result is a much more powerful tool for synthesizing new organic molecules, especially those known as alcohols that contain double bonds between carbon atoms. This widespread industrial impact would not have occurred without long-term support for the underlying science from DOE's Basic Energy Sciences (BES) office and other federal agencies.

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NANOSCIENCE How to Invent a Whole New Field

In 1980, the Nobel physicist Richard Feynman gave a lecture that proved unusually prophetic. In it, he declared that there was "plenty of room at the bottom," meaning there were huge opportunities for new science and important new technologies by exploring and manipulating materials, atom by atom by atom. Today that "room at the bottom" is called nanoscience, and it is an important part of research in physics, chemistry, materials science and biology. Moreover, you can literally see the impact of the research on TV: The current generation of video screens made by Samsung, Sony, and others use a U.S.-developed nanotechnology called quantum dots to create very high-resolution images with increasingly precise, vivid colors.

But there wasn't a clear path leading from Feynman's vision to a well-developed area of science and to commercial products. An interdisciplinary group of industrial, military and consumer product scientists gathered a team of industry, strategically placed basic research, and both government and industry supported research. In the semiconductor industry, led by Intel and others, and other electronics companies, for example, they eventually made the structure of the silicon crystal—rather than the silicon atoms—its own science, called nanotechnology. In such cases, 100 years under the watch of a science that emerged before quite differently. The industry had to develop ways to understand and cope with these behaviors.

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HOW ONE SCIENTIST CAN MAKE A DIFFERENCE

Walter Dornbush died last year a much honored legend. She was the first woman to become a tenured full professor at MIT and the first woman to win the National Medal of Science as engineering, among other things. She was a pioneer in what is now called nanotechnology, pioneering the science and fundamental properties of carbon nanotubes, finding their properties, and enabling the development of a field that has impacted across the science spectrum, from high-strength materials to cancer therapy. She also developed the science of thermoelectric energy conversion—longing science approaches that enabled portable cooling systems for nuclear submarines, among other applications. Her impact and impact in the field of nanotechnology was remarkable—from her scientific contributions to her leadership roles and her mentoring of young scientists. But some of these accomplishments were obscure from her longings.

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Transforming BIOLOGICAL SCIENCE and BIOMEDICAL PRACTICE

In 2016, more than 12,000 people in the United States died from overdoses of opioid drugs. Many of these were opioid narcotics such as heroin and morphine. But the underlying cause of this epidemic is a generally agreed to be widespread but we need perhaps new prevention of opioid drug such as morphine to control pain. People using such drugs develop a tolerance, meaning that they eventually need more of the drug to achieve the same effect and often turn to cheaper but more powerful (stronger) drugs such as heroin, which is 50 times more potent than heroin.

The epidemic opioid crisis—both prescription medicines and illegal drugs—has become a national health crisis. The epidemic of opioid abuse has become a national health crisis. The epidemic of opioid abuse has become a national health crisis. The epidemic of opioid abuse has become a national health crisis.

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SHARED RESEARCH FACILITIES A Key Source of U.S. Scientific and Industrial Leadership

In the aftermath of World War II, DOE and its predecessors built nuclear reactors used as research tools by nuclear engineers and high energy electron accelerators used by physicists to study the properties of subatomic particles. Before long, however, other scientists began to think of ways to use these facilities to study biological systems, tapping the neutron produced in a reactor core or manipulating electron beams to create intense X-rays. Soon a few scientists formed a partnership to "open" access to these facilities and attract teams of researchers to use in research with the materials they wanted to study. The results were spectacular. It rapidly became clear that such projects could provide insights into the detailed physical and electronic structure of materials that were not obtainable in any other way—including materials crucial to national security as well as other areas in a wide range of energy production.

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MAKING SUPERCONDUCTIVITY USEFUL

When you make a video call or watch NFL game highlights on your smart phone or other mobile device, the microwave signals between your phone and the mobile base station must travel millions of miles of fiber optic cables, carrying with the signal from thousands of miles of thousands of other users. A critical part of the technology that makes the base station to talk and such signals and keep your signal from being with someone else's information is superconductivity. Superconductivity is a key superconducting material that is used to transport more than 100T before freezing.

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George will be greatly missed

- Outstanding scientist
- Outstanding scientific leader
- Truly amazing citizen and leader of the BES community

