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Mr. Chairman and Members of the Subcommittee:

Thank you for the opportunity to testify before the Energy and Environmental Subcommittee. I am honored to be asked to speak about the DOE Biological and Environmental Research (BER) program and about Synthetic Genomics Inc. (SGI). I led the BER program between 1993 and 2006 and since February of 2006 I have been the President of SGI.

Genomics is the field of science that exploits new technologies and tools to allow scientists to routinely and accurately sequence the DNA of thousands of species. SGI was founded in 2005 by genomics pioneer J. Craig Venter to create genomics-driven commercial solutions that will revolutionize many industries, starting with energy. SGI is working with BP to study the microbial communities in coal beds in order to enhance the production of natural gas. Through a joint venture with the Malaysian company ACGT, a subsidiary of Genting Corporation, SGI has sequenced the genomes of Oil Palm and Jatropha to enhance yields, reduce the use of petroleum based fertilizers, and improve disease resistance of these oil seed crops.

Recently SGI announced an agreement with Exxon Mobil to harness the potential of algae to produce renewable fuels. Beyond the energy field we envision a future when synthetic genomics will be used to generate a variety of products, from new and improved vaccines to prevent human disease, to efficient and cost effective ways to provide clean drinking water. The world is dependent on science and SGI is leading the way in turning novel science into "game-changing" solutions.

During the last twenty-five years the field of genomics has undergone a rapid transformation with scientific discoveries coming at a dazzling pace. The spark for this scientific revolution was the BER initiative to sequence the human genome launched by Charles DeLisi in 1986 that led to the Human Genome Project (HGP).

The research momentum created by the HGP enabled the development of technologies such as high-throughput DNA sequencing, genome assembly, and bioinformatics. These advances, many of which are directly attributable to Dr. Venter and his teams, have enabled researchers around the world to readily sequence and analyze the genetic codes of thousands of species. In fact, it was BER that went against the prevailing scientific opinion of the time and funded Dr. Venter in 1995 to sequence the genome of *Mycoplasma genitalium* using the "shotgun" sequencing method.

Over the years the scientific partnership of BER with Dr. Venter's teams has been one of the most successful fuels of the genomics revolution. This partnership led to many accomplishments including the Sorcerer II Global Ocean Sampling Expedition – conducted by the non-profit J. Craig Venter Institute with funding from BER – which more than quadrupled the number of genes in the public data bases. I believe that BER, through support of scientists like Dr. Venter, can be credited with giving birth to the new field of synthetic genomics.

The new fields of synthetic biology, synthetic genomics, and genome engineering have the potential to spawn disruptive technologies and dramatically improve our future. These fields enable us to use living systems to tackle stubborn challenges we face in medicine, energy, and the environment. The eminent scientist Freeman Dyson used genomics as an example when he discusses the difference between a concept-driven scientific revolution and a tool-driven scientific revolution.

In his book "Imagined Worlds" Dyson wrote that in the concept-driven science we are forced to explain old things in new ways whereas in tool-driven science we discover new things that need to be explained, a far more rewarding undertaking. Genomics is the tool that has transformed biology from a strict hypothesis-driven and data-poor discipline into a discovery-driven and data-rich enterprise. BER has been on the front line of this transformation.

I am proud of my association with BER and of its many contributions over the sixty years of its existence. Formed at the dawn of the atomic era to address the impacts of ionizing radiation on human biology, it has been a trailblazer of many scientific activities. They include the fields of radiation biology, nuclear medicine, global climate change, environmental remediation, genomics, structural biology, computational biology, and

bioinformatics. In most cases, BER has not had an exclusive role and never had the greatest portion of funding among the U.S. agencies sharing that role. Nevertheless, BER has made unique contributions because it has invested in high risk but high payoff research. BER has also capitalized on its proximity and association with the physical science and high performance computing programs within the Department of Energy. BER has used its unique resources to cross-fertilize biology, physical sciences and computational power to create new opportunities for discovery. As a relative newcomer to the business world I now also recognize the value of the creative ways by which BER has engaged research partners in the private sector.

BER has never been and should never be like the National Institutes of Health (NIH) and the National Science Foundation (NSF) nor should it mimic all the functions of the other programs within the DOE Office of Science. The U.S. scientific enterprise is the best in the world because of "diversity": diversity in its scientific performers, diversity in its scientific approaches, and diversity in its funding sources. A research idea that may prove too risky or too controversial to a more mainstream funding agency should have a chance to be picked up and funded by a less risk-averse agency with very impactful results. Such is the heritage of BER and I hope this Subcommittee will appreciate this heritage and act to preserve it in the future. Every new political leadership has been tempted to "tidy up" the research activities across the government and periodically even propose a Department of Science. Thankfully, reason eventually prevails and the powers-at-be come to appreciate the value of diverse funding systems.

One of the many challenges I faced during my tenure as director of BER was the questioning of a DOE role in biology and more specifically in genomics. The questioning came from DOE leadership, from the Office of Management and Budget (OMB) and from Capitol Hill, specifically from the House Committee on Commerce and Energy. At times the questioning was in the context of why DOE should support biological research when it is mostly the primary funder of many elements of the physical sciences. At other times, there was a perceived redundancy with research activities at the NIH that is so generously funded. When the Department of Homeland Security (DHS) was formed there was an attempt to hijack the BER biology funding to support DHS R&D efforts.

I am hopeful that these dark days are over and that it is now universally recognized and accepted that BER is an important member of the U.S. scientific enterprise and that it rightfully belongs within the DOE Office of Science. The existential challenges to BER led to an in-depth examination of the contributions and potential of the BER biology programs to serve the DOE missions. BER genomics science is leading the way in the production of biological energy, including biofuels, which are considered one of the best hopes of improving our energy independence, and tackling the problem of global climate change. The BER Bioenergy Centers are the world's foremost performers in basic research of renewable fuels from biomass. BER science is central to the biological part of carbon capture and sequestration that is considered an imperative of carbon management. BER programs are also essential in environmental bioremediation that holds the greatest promise of containing DOE's cold war legacy of mixed radioactive waste.

BER plays a unique role in serving the needs of biologists from around the world who seek to access and use the scientific user facilities across the DOE National Laboratory complex and that were originally designed for the physical sciences. These include the synchrotron radiation and neutron sources, the Environmental Molecular Sciences Laboratory, and the supercomputer centers. These resources are enabling research in the fields of structural biology, structural genomics, proteomics, and computational biology. BER serves as the valuable intermediary between the biological research world and the research infrastructure of the National Laboratories that host the user facilities. A lead DOE scientific user facility is the BER Joint Genome Institute (JGI), which successfully completed the DOE contribution to the HGP. Today, the JGI is among the world's most productive sequencing centers focusing on organisms that are relevant to the DOE missions in energy and the environment.

My suggestions for continuing the tradition of successful contributions of BER in genomics sciences are:

- First and foremost, push the envelope of high risk and high payoff research. Our energy challenges are huge and even though incremental advances are important we will not be able to meet those challenges without the game-changing approaches that BER has nurtured. In many ways, BER has accomplished the biological piece of what the newly

created ARPA-E seeks to accomplish across the entire energy technologies spectrum.

- Continue to capitalize on the inherent strengths of the BER program by virtue of its existence in the bosom of the physical and computational sciences. There are still many instruments and methodologies in those sciences that BER can exploit to further propel genomics science forward.

- Enable more creative public-private partnerships in genomics involving the DOE National Laboratories and private companies. There are barriers to such partnerships such as issues of intellectual property but no barrier should be insurmountable if the tremendous value of such partnerships is recognized.

- Exploit the full potential of synthetic biology, synthetic genomics, and genome engineering by building the scientific infrastructure that will serve the diverse performers in these fields such as those from academia and the private sector. Take the lead in studying the ethical, legal, and social issues dealing with these fields.

Finally, I would like to address the stewardship role of BER for genomic science. I endorse the stewardship role of NIH in genomic science as it relates to human health and medicine. However, when it comes to genomic science that encompasses the broader living world there is no better and there will be no better steward than BER. That stewardship role of BER needs to be affirmed, strengthened, and generously funded if we are to successfully confront the great challenges of our times in energy and the environment.

I would be happy to answer questions.