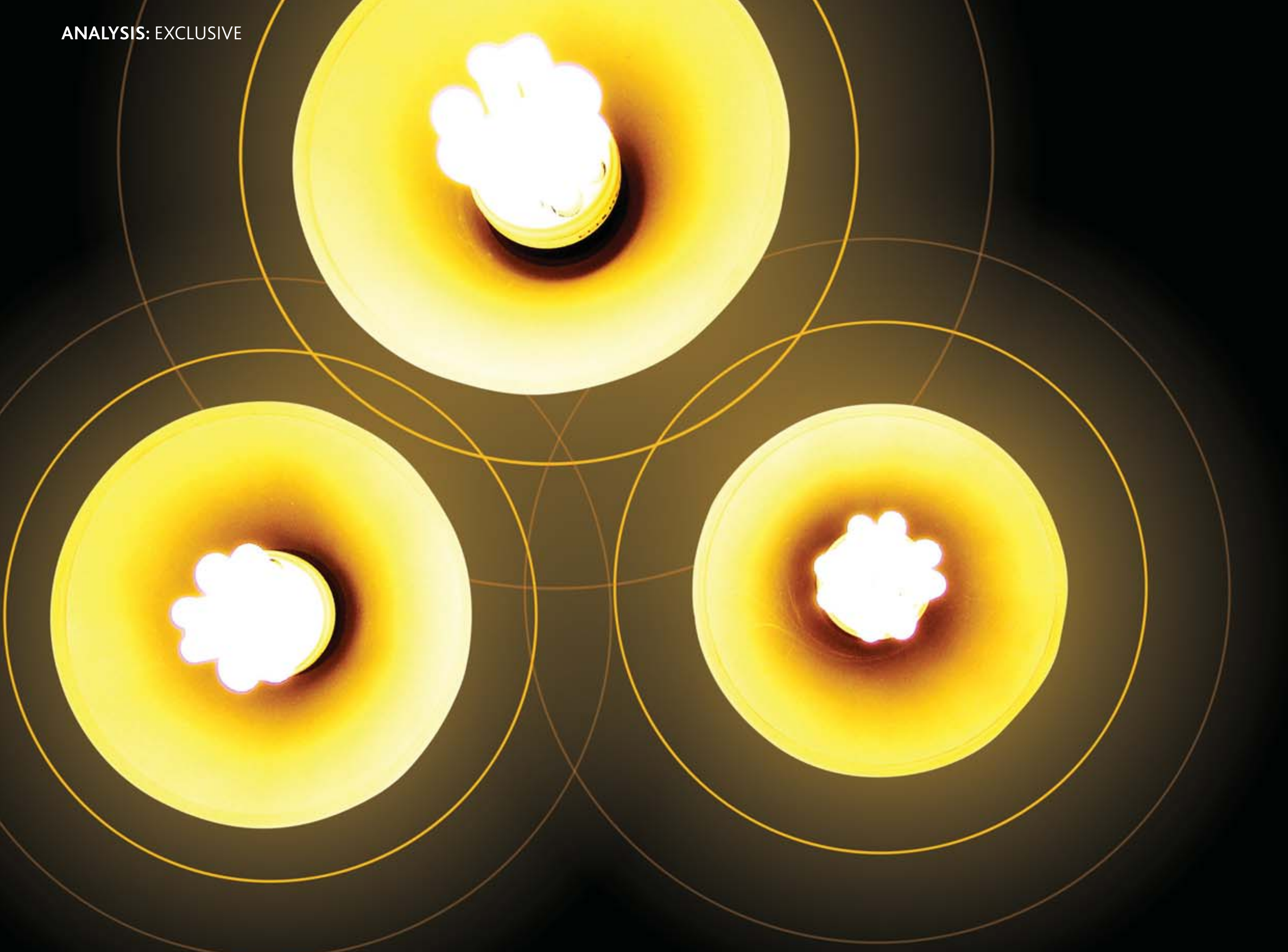

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Working towards greater energy security

As the world population continues to grow and demands on natural resources rise, research into alternative sources of energy has never been more important. **Dr William F Brinkman** outlines how the Office is working towards achieving greater energy security and provides a glimpse into some of the latest cutting-edge research in this field and the future areas that must be pursued

What is the main role of the Office of Science within the U.S. Department of Energy?

The Department of Energy's (DOE) Office of Science is the nation's largest supporter of basic research in the physical sciences at our headquarters offices and through 10 national laboratories. Over the past 60 years, we have supported research that has led to over 100 Nobel Prizes – including more than 20 Laureates just in the past 10 years.

On an annual basis, we support about 25,000 researchers at more than 300 universities and other institutions in all 50 States and the District of Columbia. We also support construction and operation of the world's largest array of advanced scientific user facilities. All in all, we provide about 45 per cent of federal funding for basic research in the physical sciences and key components of the nation's basic research in biology and computing. Finally, we are the lead federal agency supporting scientific research for energy.

In what ways does the DOE Office of Science integrate with other departments and agencies?

We have multiple cooperative efforts ongoing with other federal departments and agencies. To cite just a few examples, we are major players in the National Nanotechnology Initiative, which coordinates the activities of 25 federal agencies. We are a partner in the U.S. Global Changes Research Program, which coordinates the climate research supported by 13 federal agencies. We have a joint programme with the National Science Foundation (NSF) on regional climate modelling and a joint programme on plant genomics with the U.S. Department of Agriculture. We are part of a government-wide biomass board that coordinates research on biofuels and bio-based products. Our Nuclear Science and High Energy Physics Advisory Committees are jointly sponsored with NSF.

The DOE Office of Science is the single largest supporter of basic research in the physical sciences in the US. Could you outline some of the research projects and programmes that you are currently supporting?

The portfolio of research that we support is extremely large and varied. Our portfolio includes high energy and nuclear physics, condensed matter physics, materials science, heavy element chemistry, catalysis, and bio-geosciences. We lead the world in genomics and systems biology research for energy and the environment. We are a major supporter of climate research, and we lead the world in supercomputing for scientific applications. We are also the prime supporter of research in fusion energy sciences. With the support of thousands of researchers, we could point to any number of projects, but I would single out our Energy Frontier Research Centers, which we established on the basis of a nationwide competition in 2009. These are 46 centres that bring together interdisciplinary teams of top researchers from multiple institutions – universities, national laboratories, nonprofits, and industry – in pursuit of fundamental breakthroughs in energy-related science. In three years, they have produced more than 1,000 peer reviewed publications and are making major strides in the basic science underlying solar energy, batteries, fuel cells, and other energy areas.

You are also the main US sponsor of fundamental research in particle physics and cosmology, nuclear physics and fusion energy. Are there any noteworthy innovations that have been generated from these fields that you would like to highlight?

I would just note that while we are the main federal sponsor of research in particle physics, nuclear physics, and fusion energy sciences, we have a significant but not a federal leadership role in cosmology. The innovations that have grown out of these fields are really countless, including multiple medical applications, but if I had to choose a specific example, I would point to particle accelerator technology. Particle accelerators were developed by particle and nuclear physicists purely for purposes of discovery, but they have opened new vistas of both science and technology. Particle accelerators lie at the heart of today's advanced, large-scale x-ray light sources, which are among the premier tools we have for understanding matter – both organic and inorganic – at atomic and molecular scales. These light sources – typically large, football-field-size facilities – have turned out to be powerful tools of drug discovery, for example. Along with spallation neutron sources, which are also based on particle accelerator technology, these advanced light sources are helping us design new materials for energy and other applications and in fact yielding insights across a vast spectrum of science. At the same time, particle accelerators have become pervasive, practical tools in the world economy. It is estimated that today there are some 30,000 particle accelerators operating worldwide. They are used in the diagnosis and treatment of disease, sterilisation of foodstuffs, packaging, environmental clean-up – the applications are too numerous to list. This technology has had a major impact on the world economy, and the innovations keep coming.

How are you working towards achieving the mission of greater energy security?

We are attacking this problem aggressively, on multiple fronts – whether we are talking about solar energy, improved batteries, more efficient fuel combustion, advanced biofuels, you name it. The premise of our effort is that genuine transformation of our energy economy will require more than incremental improvement in existing technologies. It will require fundamental breakthroughs in basic science. We need game-changing discoveries to reduce our dependence on imported oil and fossil fuels generally, and that is the kind of energy-related science that we are supporting.

The Office of Science established three Bioenergy Research Centers (BRCs) in 2007. In what ways are these being utilised by researchers to develop a better understanding of the biological mechanisms underlying biofuel production?

We have three of these centres, one led by Lawrence Berkeley National Laboratory, a second led by Oak Ridge National Laboratory, and a third led by the University of Wisconsin-Madison in partnership with

Michigan State University. We have been extremely pleased with the success of the three DOE Bioenergy Research Centers. In just over four years, they have made enormous progress. The challenge they are tackling is a tough one. We want to be able to produce fuels cost-effectively from non-food plant fibre. The concept is to replace a significant portion of our petroleum-based liquid transportation fuels with home-grown fuel produced from agricultural and forest waste and specialised plants, such as switchgrass, that can be grown on marginal lands unsuitable for food production. To produce fuel from plant fibre, you first need to break down plant fibre into constituent sugars, a very tough problem. Then you need to use microbes to convert the sugars into fuels. Using the advanced techniques of genomics and metabolic engineering, the BRCs have managed to reengineer switchgrass to break down more easily and yield greater quantities of fuel. They have reengineered microbes to produce, not just ethanol – which was our original target – but actual hydrocarbon chemicals that could serve as drop-in substitutes for gasoline, diesel, and jet fuel. And they are showing how these fuels can be produced sustainably without affecting food production, while reducing lifecycle greenhouse gas emissions. But there is still a way to go. All three BRCs have been working closely with industry and will focus especially now on commercial scale-up of their discoveries, many of which are already patented or in the patent pipeline.

How important is the exchange of knowledge with the scientific research community?

We are in continual dialogue with the scientific community through several different modalities – our formal federal advisory committees, scientific workshops and meetings, and informal discussions between researchers and our DOE programme managers. We seek the community's help, on an ongoing basis, in understanding scientific opportunities and challenges and work to find a bridge between those scientific opportunities and challenges, on the one hand, and DOE's mission goals in energy and other areas, on the other.

What would you define as the main societal benefits of the work undertaken by the Office of Science?

In 1945, Vannevar Bush, who was then the President's science advisor, wrote a report to President Truman called Science: The Endless Frontier. In the report, he argued for large-scale federal support of scientific research, which was a new departure for our country at the time. Our origins as an office can be traced back to those days and to the decision of the US following World War II to invest heavily in science for the first time in our history. Bush wrote: "Without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world". As a mainstay of federal science funding, we have been a major contributor to underwriting the prosperity and security of the nation over the past 60 years. Examples include superconducting magnet technology, radioisotopes, battery materials, semiconductor processing, and many others.

Which areas of research do you believe need to be pursued further in order to tackle issues associated with clean energy production?

Energy technology draws on practically all the fundamental sciences: physics, materials science, chemistry, and even biology and genomics. Modelling and simulation using high-performance computing have also become powerful tools in energy-related research. We need transformational discoveries in all these areas to build a clean energy economy.

Where would you like to see the Office of Science in the future?

In our emphasis on the energy mission, we need to be careful to maintain a balance between 'use-inspired' or more applied-oriented research, on the one hand, and discovery research, on the other. The benefits of discovery research, of research rooted in pure scientific curiosity, are sometimes hard to see in the short run. But discovery research remains the wellspring from which use-inspired and applied research ultimately draw their insights. Continued progress in discovery research is essential to nourish and replenish the more applied work. Especially in times of tight budgets, it is important that we maintain support for investigators who are simply probing the fundamentals.

US expenditure on research and development has fallen significantly in the past two years, prompting the Department of Commerce to call for heightened investment to support this critical driver of the nation's economy. Do you feel that there is sufficient support and financial provision for R&D, and how has the current economic climate affected your research?

There is no question that we are in a tougher budget climate today than we were a few years ago. At the same time, the Obama Administration has made clear that federal support of science remains vital to the future of our Nation and is an Administration priority. The Administration has provided support for increases in our budget even in these lean times, and Congress, too, has been generally supportive of federal investments in science. I think that is a positive sign and a smart course of action for our country, and I hope we stick with it in the years ahead.

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