Statement of

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Thank you, Chairman Baird, Ranking Member Inglis, and Members of the Committee for the opportunity to appear before you to provide testimony on "Biological Research for Energy and Medical Applications at the Department of Energy Office of Science." In 1990, I became affiliated with the Department of Energy's (DOE's) national laboratory system as a post-doctoral chemist at the Pacific Northwest National Laboratory (PNNL) in Richland, Washington. Since that time, I have spent nearly 20 years at PNNL as a senior research scientist, a technical group leader and, as of 2000, the Associate Director of EMSL—the Environmental Molecular Sciences Laboratory. In May 2005, I was named EMSL Director.

Today, my testimony will focus on three objectives: (1) introducing you to EMSL, its mission, its users, and the science it enables; (2) articulating the role of EMSL in supporting the biological research efforts of DOE's Office of Biological and Environmental Research (BER) and other agencies; and (3) describing future opportunities that will accelerate scientific discovery at EMSL.

History of EMSL

Located at PNNL, EMSL is a BER-funded national scientific user facility. The concept of EMSL began in 1986, when then-PNNL Director Dr. William R. Wiley and his senior managers met to discuss how PNNL could respond to the scientific challenges that faced DOE. Dr. Wiley and his senior leadership team, knowing of the tremendous advances made in the ability of the research community to characterize, manipulate, and create molecules, believed that molecular-level research would be instrumental to solving significant challenges in the environment, energy, and health arenas. The resulting concept was a center for molecular science research that would bring together experimentalists from the physical and life sciences and theoreticians with expertise in computer modeling of molecular processes.

Dr. Wiley's vision was realized in July 1994 when construction began on the William R. Wiley Environmental Molecular Sciences Laboratory, as it came to be called, and the building was dedicated in October 1996, shortly after he passed away unexpectedly. The doors of EMSL opened to the user community on October 1, 1997.

The Uniqueness of EMSL

Today, Dr. Wiley's vision continues to be embodied in EMSL's mission to provide researchers worldwide with integrated experimental and computational resources for scientific discovery and technological innovation in the environmental molecular sciences to support the needs of DOE and the nation. EMSL is unique in that if offers users a problem-solving environment that integrates scientific expertise with transformational capabilities to enable the highest-impact scientific results possible. These capabilities include, under one roof, high-performance computing tools that advance molecular science in areas such as aerosol formation, bioremediation, catalysis, climate change, and subsurface science; high-resolution microscopes that enable scientists to visualize molecules and molecular processes; and world-leading nuclear magnetic resonance (NMR) and mass spectrometry capabilities that allow researchers to characterize complex systems such as microbial communities.

Many of these capabilities are built in house, another feature that sets EMSL apart from other facilities. For example, the EMSL-developed NWChem, DOE's premier computational chemistry software, runs on systems such as EMSL's high-performance, third-generation supercomputer, Chinook—an HP system that can reach 163 teraflops in peak performance. Researchers apply NWChem to run highly scalable, parallel computations to gain understanding of large, challenging scientific problems such as the biological activity of reactive sites in proteins, providing insight into how they carry out critical functions such as DNA repair. Another example is EMSL's STORM – an optical microscope that allows users to observe biological systems in natural environments at electron microscopy resolution, without altering the material from it natural state as required by electron microscopy.

However, world-class instruments are only one component of a world-class facility. The most important aspect of EMSL is the cadre of leading scientific and technical experts. EMSL scientists have been recognized with the Presidential Early Career Award for Scientist and Engineers, and they have been elected as Fellows in a variety of professional societies such as the American Chemical Society and the American Association for the Advancement of Science. They serve as editors on scientific journals, have patented several new technologies, and publish their work in leading scientific journals. Our researchers have dedicated their careers to building new and innovative technologies, pushing the limits of scientific discovery and advancing the science of our users.

These capabilities and scientific expertise are focused to support DOE's missions in energy and environment and address complex challenges within EMSL's three science theme areas: (1) Biological Interactions and Dynamics, (2) Geochemistry/Biogeochemistry and Subsurface Science, and (3) Science of Interfacial Phenomena.

Biology Research within BER and other Federal Agencies

DOE's Office of Science is the single largest supporter of basic research in the physical sciences in the United States, providing more than 40 percent of total funding for this vital area of national importance. Within the Office of Science, BER sponsors, supports, and advances world-class biological and environmental research programs and scientific user facilities to drive fundamental science discoveries and to meet its mission priorities to:

- Develop biofuels as a major secure national energy resource
- Understand relationships between climate change and the Earth's ecosystems, and assess options for carbon sequestration
- Predict fate and transport of subsurface contaminants
- Develop new tools to explore the interface of biological and physical sciences.

In addition to DOE's Office of Science, the National Science Foundation (NSF) and National Institutes of Health (NIH) fund research programs in the biological and health sciences. Scientists funded by these programs advance their research with the help of DOE's national scientific user facilities, such as EMSL. EMSL is particularly well positioned to foster discovery in the biological sciences for these researchers because of its strong focus on providing transformational capabilities. Such capabilities at EMSL offer researchers new approaches to view chemical and biological systems—from **single molecules or organisms to complex structures or communities**, from **static to dynamic** processes, and from ***ex-situ*** **systems to *in-situ* observation**. These capabilities and EMSL's world-leading scientists are helping researchers unravel complex biological problems such as the following.

- **Understanding the light path to bioenergy**. Using EMSL's world-leading high-throughput proteomics resources, a team led by researchers from **Washington University in St. Louis** discovered a novel cluster of genes that encode proteins essential for photosynthesis. This discovery is providing insight into how nature converts light into energy, a reaction of interest because future clean energy sources will rely heavily on this conversion.

- **Understanding how oceanic microbial communities are optimized for nutrient uptake**. EMSL's world-leading proteomics resources were critical to pioneering research in which EMSL users from **Oregon State University, the University of California and PNNL**, for the first time, measured protein expression in microbial communities from the Sargasso Sea. The insight afforded by this research into oceanic microbial communities is important because such bacteria heavily influence biogeochemical cycles, affecting the concentrations of elements such as carbon—and therefore the greenhouse gas, carbon dioxide —in the Earth's air, water, and soil.
- **Fundamental studies give insight into ocular function.** The eyes house the elegant machinery that responds to light and triggers the neural impulses that allow us to visualize our surroundings. Researchers from the **University of Washington** have used EMSL's NMR spectrometers and sophisticated probe technologies to gain new knowledge about the complex visual system at the molecular level. The team is the first to determine a high-resolution structure of a photoreceptor domain that affects how quickly the eye can see. Studies such as this one are the first steps toward a fundamental understanding of the how the visual system works and how to fix it when it goes awry.
- **Identifying newly found proteins that may indicate if breast cancer cells will resist treatment**. Researchers from **Erasmus Medical Center Rotterdam** combined EMSL's mass spectrometry capabilities with EMSL expertise in proteomics to identify 55 proteins that vary in abundance between patients responsive to the breast cancer treatment tamoxifen and those who are not, indicating that a biomarker for resistance to this drug might exist.
- **Developing new tools to aid in understanding the physiology of live cells.** A research team from **PNNL, The J. Craig Venter Institute, and Merck Co., Inc.,** used EMSL resources to develop a first-of-its-kind MRI biochamber that provides accurate metabolic information for live cells maintained in a controlled growth environment. This new capability is helping researchers understand the processes employed by microorganisms under different conditions, an important step in using these microbes to manufacture biofuels and other valuable chemicals from waste.
- **Investigating how bacterium immobilizes subsurface contaminants.** An international team used EMSL's surface science and imaging capabilities to determine the location, with nanoscale resolution, of two proteins on the surface of the bacteria, *Shewanella oneidensis*. These proteins help *Shewanella* exchange electrons with minerals in the subsurface, which can affect the migration of environmental contaminants. Understanding the role of these proteins in electron exchange may lead to enhanced bioremediation methods. The team was comprised of participants from **The Ohio State University; PNNL; Corning Incorporated, Johannes Kepler University of Linz, Austria; Ecole Polytechnique Fédérale de Lausanne, Switzerland; and Umeå University, Sweden**.

Future Opportunities

BER continues to make significant investments in EMSL to keep the user facility unique and state of the art. Perhaps the greatest vote of confidence in EMSL and our ability to serve the user community is BER's recent investment of $60 million in American Recovery and Reinvestment Act funds, which will accelerate planned recapitalization activities and condense the effort from more than 5 years to 18 months. This investment represents a "game changer" for EMSL in that it allows us to push forward critical, cutting-edge capabilities for *in situ* chemical and biological imaging, ultra-high resolution microscopy, near-real-time integration of theory and experiment, and characterization of molecular dynamic processes. These new high-end capabilities will bolster and refresh our user program and our users' research and allow EMSL to attract and retain vital scientific leadership. Our efforts are under way, and the instruments will be in our facility by December 31, 2010.

We are also collaborating with the National High-Field Magnetic Laboratory at Florida State University and the Atomic and Molecular Physics Institute in the Netherlands to develop the world's highest-field Fourier Transform-Ion Cyclotron Resonance mass spectrometer. This high-field magnet would make the scientifically impossible possible through increased analytical performance—sensitivity, dynamic range, accuracy, resolution, and speed/throughput. Such a system has the potential to revolutionize our biomolecular understanding of how organisms function and how microbial systems cooperate as communities by allowing our users to qualitatively identify and measure intact proteins, the machinery of life. The magnet would also allow our users to better investigate complex environmental samples such as fossil fuels and atmospheric aerosols. New knowledge garnered from this instrument would have applications to energy and environment problems of national significance. For example, it would help enable biofuel development and foster better-informed technical and policy decisions affecting environmental remediation, waste processing, energy production, and associated health impacts.

In concert with the unique instrumentation at EMSL, BER has provided the user facility with much needed critical infrastructure support. They are making investments for the development a radiochemistry capability that will serve a broad and growing base of users who require instrumentation in a radiological environment to further their studies of chemistry and biogeochemistry of actinides, fission products, and the use of radiotracers for biological research. In addition, EMSL will build a new space that will house ultra-high-resolution instruments for providing physical and chemical information at unprecedented spatial or energy resolution. Called the Quiet Wing, it will house new microscopy capabilities that require extremely low electromagnetic field and vibrational interference as well as high-temperature stability.

EMSL Users

Of course, EMSL would not exist without its user base. Users can access EMSL to perform either non-proprietary or proprietary research. There is no charge for access to EMSL if the research is considered non-proprietary, meaning that researchers will publish the results in the open literature and acknowledge EMSL's contribution. However, if the research is proprietary—the results are to be confidential—the user will pay full-cost recovery of the facilities used, which includes, but is not limited to, labor, equipment use, consumables, materials, and EMSL staff travel.

During our 12 years of operation, we have hosted more than 10,000 scientists from all 50 states and more than 60 countries, including many countries from Asia, most European countries, and Australia. Many of these users—nearly half—come from the university system.

Another large user set of EMSL capabilities is scientists from the government sector, including the DOE national laboratory system, NASA, the Department of Defense, and the Department of Agriculture. Finally, members of industry comprise a much smaller sector of EMSL's user base due mostly to the proprietary nature of their research. These entities include, for example, Bayer Polymers, 3M, Ford Motor Company, and Dow Chemical Company.

In terms of agencies that fund the projects of EMSL users, most—nearly 45 percent—are funded by DOE; and one third of these DOE projects are funded by BER. The NIH and NSF fund approximately 25 percent of projects at EMSL, and the balance is funded from a variety of sources, such as the Department of Defense, Department of Agriculture, and private industry.

EMSL users range from undergraduate and graduate students to post-doctoral fellows and research scientists and engineers. EMSL strives to bring in the best and brightest users to conduct the highest-impact science possible. We have counted among our users 160 distinguished scientists—including 11 National Academy members, 32 endowed chairs, 2 Nobel laureates, and 131 authors who are considered top publishers over a 10-year span.

We have had many users from the states that the members of this committee represent; for example, during the history of EMSL, we count among our users more than 20 researchers representing the University of South Carolina and Westinghouse Savannah River. Nearly 120 of our users call Texas their home and represent institutions such as University of Texas at Austin, Texas A&M, and Baylor College of Medicine. From Illinois, 90 researchers from institutions such as Argonne National Laboratory, the University of Illinois, and the University of Chicago have benefited from use of EMSL's capabilities and expertise. And in our home state of Washington, EMSL has been an excellent scientific resource for more than 2,300 researchers not only from PNNL, but also institutions such as the University of Washington, Washington State University, and the Fred Hutchinson Cancer Research Center.

We continue to conduct outreach activities to grow our user base. This is done through colleague-to-colleague interaction, contact at professional society meetings, and development of programs such as the Wiley Visiting Scientist Fellowship and EMSL Distinguished User Seminar Series, among others.

Scientific and Technological Output

Since Fiscal Year 2007 alone, EMSL-based research and discoveries have been the subject of nearly 1,000 papers in peer-reviewed journals, with 57 percent of them in top-10 journals and 13 of them in top-tier journals such as *Science, Nature*, and *Proceedings of the National Academy of Sciences*. Since that time, research at EMSL by our users and staff has been featured on more than 30 journal covers, including *Science, Physical Chemistry Chemical Physics (PCCP), ACS Nano, Nanotechnology*, and *Proteomics*. These statistics help illustrate the broad scientific impact enabled by EMSL.

Concluding Remarks

To summarize, with continued support and investment from BER in the user program, EMSL will continue to bring Dr. Wiley's vision to fruition by providing the scientific community worldwide with the unique ability to integrate capabilities and staff expertise for achieving the highest-impact science.

Thank you, Mr. Chairman, for providing this opportunity to discuss EMSL and DOE's biological research programs. This concludes my testimony, and I would be pleased to answer any questions you might have.