AMERICAN SOCIETY FOR MICROBIOLOGY

Response to Bioeconomy Blueprint RFI
American Society for Microbiology
December 6, 2011

The American Society for Microbiology (ASM) welcomes the opportunity to respond to the OSTP's request for comment on the development of the National Bioeconomy Blueprint. ASM represents nearly 40,000 microbiologists with a remarkably broad range of expertise, as befits a group studying Earth's most diverse and prolific life forms.

Microbes are essential to the emerging bioeconomy. Why? Because they are:

- A virtually inexhaustible source of biodiversity, metabolic ingenuity, and natural products;
- Workhorses for the production of industrial catalysts and pharmaceuticals from insulin to antibiotics to vaccines to probiotics;
- A promising source of the next generation of environmentally and politically neutral fuels;
- Required partners for all plant growth, making microbes an untapped resource for adapting crops to grow in more places with fewer inputs;
- Critical drivers of the Earth's biogeochemical cycles and therefore important players in the climate change realm, both as sentinels and, potentially, as mitigators;
- Providers of the chassis and parts sets for synthetic biology;
- The ultimate model organisms for molecular and cellular biology, making possible the spectacular advances in health and biotechnology born out of those disciplines.

Microbes are even more significant when we consider the economically and socially critical health care sector. Interactions between humans and microbes are essential to our well-being, most notably in areas that do not involve the role of microbes in infectious diseases. The vast and beneficial microbial communities that live in our guts and on our skin have profound effects on metabolism, immunity, and behavior. Understanding the role of our microbial partners is crucial to treatment of allergies, asthma, obesity, and auto-immune disorders. Thus, in-depth investigation of the central role microbes play in these and other conditions is vital to the development of novel therapeutics.

In short, if America is going to build a thriving bioeconomy, its success will hinge on understanding and development of the capabilities of the microbial world.

In recent years, numerous groups that span diverse scientific disciplines have proposed sets of "Grand Challenges" that humanity faces. What is particularly striking is the clear consensus that microbial sciences are crucial to meeting the majority of these challenges irrespective of the scientific group putting forward the challenge. We refer the reader to the box outlining a small sample of challenges from the Gates Foundation and other organizations and fields. We note that many other grand challenges from these and other organizations rely on microbial sciences. Indeed, in the recent National Academies report, "A New Biology for the 21st Century" all four of the suggested grand challenges have significant microbiological components. The imperative for microbiologists today is not to articulate microbiology's grand challenges, but rather to ensure that microbes' contributions to the nation's bioeconomy blueprint are fully realized.

Samples of Grand Challenges that rely on microbial science:

The Gates Foundation *Grand Challenges in Global Health*:

- Create effective single dose vaccines that can be used soon after birth
- Devise reliable tests in model systems to evaluate live attenuated vaccines
- Learn which immunological responses provide protective immunity
- Develop a biological strategy to incapacitate a disease-transmitting insect population
- Create a full range of optimal, bioavailable nutrients in a single staple plant species
- Discover drugs and delivery systems that minimize the likelihood of resistant microorganisms
- Create therapies that can cure latent infection
- Create immunological methods that can cure chronic infections
- Develop technologies that permit quantitative assessment of population health status
- Develop technologies to allow assessment of many conditions and pathogens at point-of-care

Grand Challenges for Engineering (National Academy of Engineering)

- Make solar energy economical
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Engineer better medicines

A New Biology for the 21st Century (NRC, 2009)

- Food: Generate food plants to adapt and grow sustainably in changing environments
- Health: Understand individual health
- Energy: Expand sustainable alternatives to fossil fuels
- Environment: Understand and sustain ecosystem function and biodiversity in the face of rapid change

New Horizons in Plant Biology (NRC 2008)

- A scalable view of global regulatory networks arrived at by collection of system-wide data sets from naturally variable genotypes assessed across growth and stress conditions, and in association with other organisms
- Families of models incorporating these datasets that both describe system behavior and predict outcomes of subsequent system perturbations
- Validate computational representations of individual plant cells, tissues, and, eventually, whole plants interacting within their multiorganismal communities

From Molecules to Minds: challenges for the 21st century (IOM 2008)

- How does the interplay of biology and experience shape our brains and make us who we are today?

Grand Challenges in Environmental Science (NRC 2001)

- Understand how the Earth's biogeochemical cycles are being perturbed by human activities
- Understand the regulation and functional consequences of biological diversity, and to develop approaches for sustaining this diversity and the ecosystem functioning that depends on it
- Increase our ability to predict climate variability to understand how this variability may change
- Predict changes in freshwater resources and the environment caused by floods, droughts, sedimentation, and contamination in a context of growing demand on water resources
- Understand the ecological and evolutionary aspects of infectious diseases
- Develop a systematic understanding of changes in land uses and land covers that are critical to biogeochemical cycling, ecosystem functioning and services, and human welfare
- Develop a quantitative understanding of the global budgets and cycles of key materials used by humanity and of how the life cycles of these materials may be modified

The microbial sciences are highly interdisciplinary, incorporating, for example, molecular biology, cellular biology, physics, geology, chemistry, materials sciences, and engineering. This rich history is emblematic of a profound and general change in science and technology over the past 20 years. The interdependence of scientific and engineering disciplines and the potential advantages of interdisciplinary collaboration have never been greater. Yet, the traditional organizational structures of academia and government continue to make collaboration difficult. Building a sustainable bioeconomy will require integrating expertise across disciplines and reducing the existing barriers that discourage academia, industry, and government from working together to achieve common goals. The OSTP's RFI asks for input on such questions as what grand challenges the bioeconomy could tackle, what federal funding priorities will be needed to achieve the bioeconomy, what technical challenges must be solved, how the private, public and academic sectors can best work together, and how graduate training should evolve to meet the needs of the future. Without mechanisms to convene all of the different stakeholders who can contribute to meeting a grand challenge, advancing an industry, or developing a new technology the blueprint will fail. As a Society, we stand ready to help, by identifying microbial scientists to contribute to any such community consensus-building mechanisms, by helping to improve communication across microbial programs housed in different agencies, and by mobilizing our members to embrace and contribute to the development of a lasting bioeconomy.

Three areas seem particularly crucial to success. First, the efficiency resulting from coordination and communication across the federal government has the potential to multiply the value of all research funded by different agencies. Discoveries made by microbiologists working on optimizing biofuel production could propel the research of microbiologists studying human health, and the fundamental research on microbial physiology and ecology supported by the NSF could be translated into revolutions in applied research in multiple areas. However, it is difficult at present for these communities to benefit from each other's advances, form productive collaborations, or identify common infrastructural needs and transformative technologies. As a result, the US is not reaping the full value of federal investment in research. This problem is not unique to microbiology, but because of the inherent interdisciplinary nature of microbiology and its impact on all realms of the emerging bioeconomy, microbiology could serve as an excellent prototype for the development of cross-agency communication and coordination endeavors. Again, the ASM would be eager to identify appropriate individuals from across the field of microbiology to contribute to such an effort.

Building bridges for communication across microbiological communities would begin to address a second, fundamental need: identifying and developing infrastructural resources that would benefit most if not all scientists. Again, we offer microbiology as a model for all disciplines. From highly transparent, searchable and manipulable databanks, to new imaging and high-throughput spectroscopy technologies, to long-term environmental data collection efforts, many investments exceed the scope and resources of any one federal agency, but collectively funding them would improve the productivity of all scientists and leverage the value of their combined research. Identifying and jointly investing in such infrastructural projects would speed the emergence of a bioeconomy.

Third, the Society agrees that focused grand challenges are essential as they can have a transformative effect, often well beyond their stated goals. The Human Genome Project provides a perfect example: the technological advances spurred by that project revolutionized microbiology, revealing a treasure trove of microbes that were invisible before inexpensive, high-throughput sequencing made it possible to detect the microbes that live everywhere on Earth, but do not grow easily in laboratories. In turn, this newly discovered microbial diversity has contributed to advances in bioremediation, natural product discovery, biofuel production and many other applications. Microbiology is poised to make huge contributions to such challenges as increasing crop productivity with fewer inputs and sustainable production of liquid fuels. Irrespective of the grand challenges that are selected as the pillars of the bioeconomy blueprint, the ASM is certain that

microbiology will be central to its success, and we look forward to contributing our effort and talent to making the blueprint a reality.

Finally, through its colloquium program, the American Academy of Microbiology has explored the role of microbiology in many important societal issues. Colloquia generate objective, independent, peer-reviewed reports that are made publicly available at no cost. Many of these reports explore how microbiology can contribute to solving important grand challenges, for example:

- Incorporating Microbial Processes into Climate Change Models (2011 forthcoming)
- Global Food Safety: Keeping Food Safe from Farm to Table (2010)
- Bioinformatics and Biodefense: Keys to Understanding Natural and Altered Pathogens (2009)
- Antibiotic Resistance: An Ecological Perspective on an Old Problem (2009)
- Clean Water: What is Acceptable Microbial Risk (2007)
- Microbial Energy Conversion (2006)
- Microbial Triggers of Chronic Human Illness (2005)

An important benefit of the colloquium format is that it provides a venue for microbiologists to meet with scientists from other disciplines, educators, administrators, public servants, engineers and others to consider challenges from many different perspectives, generate new ideas and devise common approaches. Such a format would be a fruitful way to address the questions posed in the Bioeconomy Blueprint RFI – each of which would benefit from collective brainstorming among many different constituencies. Relying on its more than 15 years of experience with this format, the ASM would be happy to aid the OSTP in convening groups who can further define the bioeconomy blueprint.

Respectfully submitted on behalf of the American Society for Microbiology

David Hooper, President of the American Society of Microbiology
Roberto Kolter, Chair of the ASM Public and Scientific Affairs Board
Bonnie Bassler, Chair of the Board of Governors, American Academy of Microbiology