

The Purdue University “Predicting and Controlling Microbiomes for Health, Industry and the Environment” Symposium

Proposers/Co-Organizers:

College of Agriculture (Karen Plaut)

Department of Food Science (Steve Lindemann, Brian Farkas)

Department of Animal Science (Tim Johnson, Alan Mathew)

Department of Entomology (Laramy Enders, Stephen Cameron)

Department of Agronomy (Cindy Nakatsu)

Department of Agricultural and Biological Engineering (Mohit Verma, Bernie Engel)

Confirmed Cross-College Steering Committee:

Health and Human Sciences: Connie Weaver, James Fleet, Qing Jiang, Nana Gletsu-Miller

Engineering: Doraiswami Ramkrishna, Kevin Solomon

Veterinary Medicine: Yava Jones-Hall

Liberal Arts: Amanda Veile, Andrew Flachs

Purpose of the Symposium and its relationship to Purdue Moves:

Microbial communities have been studied in their native ecosystems since Antonie van Leeuwenhoek’s first observation of “animalcules” in the 1670s. Recent advances in high-throughput DNA sequencing approaches have enabled unprecedented ability to catalog and understand microbes independent of cultivation, which has revolutionized the study of communities of microorganisms (i.e. microbiomes) in the natural environment, industrial and agricultural processes, and human biomedical arenas. As a result, microbial communities are now recognized for their links to human, animal, and plant health, fueling demand for translational research in these spheres.

Although we are currently experiencing an extraordinary boom in microbiome research, translation of groundbreaking discoveries linking microbiomes to animal, plant and environmental health has lagged. Microbiome research centers and initiatives have sprung up at universities around the country to centralize expertise and integrate researchers with common scientific objectives across a broad array of sub-disciplines within microbial ecology, but few

such efforts are aimed at application. Currently, there is a need for focused efforts across the greater microbiome research community that move beyond characterizing microbial communities and begins to explore innovative ways to apply our knowledge of microbial ecosystems for the improvement of human health and agricultural production. This challenge echoes the Purdue Moves vision of “...mak[ing] discoveries that have a critical impact in the real world – not just in the lab.” We therefore propose a “Predicting and Controlling Microbiomes for Health, Industry and the Environment Symposium” to highlight Purdue’s contributions to advancing applied microbiome research and fuel further growth in the area of microbiome management and engineering. The proposed symposium represents an opportunity to exert Purdue’s STEM leadership in an emerging field ripe for engineering applications.

The Purdue microbiome research community is poised to establish itself as a global leader in a focused, applied sub-discipline of microbiome studies – prediction and control of the microbiome, enabling rational management and engineering. Broadly defined, this sub-discipline *aims to develop the knowledge and tools required to predict and control the behavior of diverse microbiomes for improved health, economic benefit, and environmental sustainability.* If successful, development of a critical mass of research in the microbiome management and engineering space would invite cross-College participation (an expected ~400 total attendance, the majority Purdue faculty, students, and post-docs) and position Purdue among elite, translational microbiome centers. We therefore propose a microbiome management and engineering-focused symposium with the following goals:

- 1) Establish Purdue as a leader in the management of microbial ecosystems for the improvement of human health, industrial processes, and environmental sustainability.
- 2) Showcase Purdue’s multi-disciplinary microbiome research community
- 3) Generate networking opportunities for Purdue researchers and leading scientists in microbiome research

Applied microbiome research at Purdue: Value to Purdue and external scholars

Purdue is home to a diverse microbiome research community that spans multiple disciplines. The recent strategic hiring of several faculty with microbiome-focused research programs throughout the College of Agriculture, (Food Science, Entomology, and Animal Science) has created the momentum that inspired the proposed symposium.

Hosting a focused symposium is the next step in a strategy to advance a critical mass of microbiome management and engineering research at Purdue, unify the microbiome research community on campus, and achieve institutional recognition for Purdue as a leader in this field. Such an effort would unify world-renowned Purdue centers and other scientific expertise (e.g., the Whistler Center for Carbohydrate Research as well as diverse, leading research programs from animal nutrition to metabolic modeling), with recent investments in microbiome-relevant life sciences (e.g. PI4D, Drug Discovery) and research infrastructure (Purdue Genomics Core, Bindley Bioscience Center, Gnotobiotic Facility, PULSe) The goal of such an approach is to generate a swarm of like-minded individuals who collaborate organically, leveraging their diverse expertise sets on a shared problem. Initially, we submit that the proposed multi-disciplinary symposium would unify microbiome scientists internally and promote Purdue's institutional reputation by recruiting high-profile academic and industrial thought leaders to discuss the broader idea of microbiome management and engineering as well as specific technological advances in this space. Furthermore, such a symposium would draw faculty from regional institutions with interest not just in microbiomes, but, further, in prediction and control of their behavior. This confluence of like-minded researchers will support Purdue as the Midwest hub for microbiome management and engineering, a vacuum that currently exists as more-established centers are on the coasts.

Symposium Plan

We envision a two-day symposium that hosts world-renowned researchers at the forefront of microbiome research, particularly those viewed as shaping the direction and future of microbiome management and engineering in spheres central to Purdue's historical strengths in human, animal, plant, and environmental health. The symposium will have six main sessions organized around microbiome application areas (human, animal, plant, insect, soil, and engineering). Each session will include technical talks by invited participants, invited abstracts, and Purdue faculty. At the close of each day's sessions, presenters in each session (e.g., human gut, soil) will lead concurrent breakout vision-casting discussions moderated by Purdue chairs, to discuss views on where microbiome prediction and control is headed within that space. Informal networking would be planned over meals and breaks. In addition, we propose to include a more structured networking session centered around an early evening poster session highlighting the research of Purdue faculty, students and post-docs, but also open to submitted abstracts from other attendees. Especially interesting abstracts would be invited to short oral presentations to be included in the first morning session of talks, which will incentivize junior faculty from Purdue and neighboring institutions to submit abstracts. The two-day format permits participants to continue their informal interactions over dinner. Furthermore, a dinner for invited participants and Purdue organizers would facilitate interactions between the Purdue applied microbiome research community and world-renowned leaders in the field. After the conference concludes mid-afternoon on the second day, we will immediately convene an internal meeting for Purdue faculty to organize around the ideas presented in the symposium and nucleate new ideas and collaborations.

Potential External Invited Speakers

We plan to invite world-renowned experts in translating microbiome science relevant to research within the Colleges of Agriculture, Health and Human Sciences, Science, and Engineering. The speakers we have selected are recognized for their contributions to advancing the manipulation of microbial ecosystems for human, animal, plant, and soil health as well as industrial processes. We propose a slate of speakers that combines pioneering individuals in various fields with up and coming scientists at the forefront of microbiome management and engineering-focused research. Our goal is to showcase Purdue applied microbiome research alongside other groundbreaking researchers.

Justin Sonnenburg (Stanford University): Leading scholar in dietary influence on the gut microbiome and adaptation of engineering approaches to the gut microbiome, author of a recent microbiome engineering perspective published in *Nature*, and a recent recipient of the both the NIH New Innovator and Pioneer Awards. Dr. Sonnenburg's work has revealed how intake of microbially-available carbohydrates governs the risk of both acute and chronic disease.

Nancy Moran (University of Texas at Austin): Expert in the evolution of insect-microbe interactions. Dr. Moran is a member of the National Academy of Sciences and is most recognized for her pioneering work uncovering the metabolic interdependence of aphids and the bacterial endosymbiont *Buchnera aphidicola*. Dr. Moran's work has also led to key discoveries linking the microbiome and honeybee health.

Jeff Dangl (University of North Carolina): Internationally recognized for his contributions to the field of molecular plant pathology. Recent research has focused on links between plant-associated microbial communities and disease resistance. Dr. Dangl is a John N. Couch distinguished professor of biology and member of the National Academy of Sciences and American Academy of Microbiology.

Heather Allen (USDA ARS National Animal Disease Center): Leading scholar making breakthroughs in animal microbiome and virome structure/function and manipulating the gut microbiome in swine for disease prevention, improving food safety and understanding and reducing antibiotic resistance in animals. She was recently awarded the Herbert L. Rothbart Early Career Scientist Award recipient for the Agricultural Research Service, USDA.

Jim Collins (MIT and founder of Synlogic, a microbiome startup company): Leading inventor in genetic engineering of gut microbes and their use as therapeutics. Dr. Collins is a member of the National Academies of Sciences and Engineering, the Institute of Medicine, the American Academy of Arts and Sciences, a charter fellow of the National Academy of Inventors, and a recent recipient of an Allen Distinguished Investigator award.

Mary Firestone (University of California, Berkeley): Leading scientist in the field of soil microbial ecology and applications to ecosystem sustainability, response to climate change and biofuel production. Dr. Firestone was recently elected to the National Academy of Sciences and has received several Career Achievement Awards from the Soil Ecology Society and Berkley College of Natural Resources.

Potential Purdue Speakers and Moderators

College of Agriculture: Drs. Enders, Johnson, Lindemann, and/or Nakatsu (interactions of insects, poultry, and humans with their respective microbiomes); College of Engineering: Dr. Ramkrishna (modeling microbiome metabolism), Dr. Solomon (metabolic engineering), Dr. Verma (metabolic interactions in microbiomes); College of Health and Human Sciences: Dr. Weaver (fiber-microbiome interactions in bone metabolism), Dr. Gletsu-Miller (microbiome involvement with bariatric surgery), Dr. Jiang (microbiome and vitamin E), Dr. Fleet (vitamin D and microbiome); College of Veterinary Medicine: Dr. Jones-Hall (Crohn's disease and the microbiome); College of Science: Dr. Gribskov (computational approaches to microbiomes), Dr. McCabe (statistical approaches to microbiome science); College of Liberal Arts: Dr. Veile (microbiome and birth modes in indigenous populations), Dr. Flachs (microbiome and fermented foods)

Potential for Media Attention, Scientific Publications, and Future Funding

The microbiome is an incredibly hot topic in the national news media. Articles on the microbiome have appeared in a multitude of media outlets, including popular science (e.g. *Scientific American*), cultural (e.g. *The Atlantic*), and news (e.g. *The New York Times*) publications. The proposed list of speakers is expected to generate both scientific and popular media interest, and invitations will be sent to journalists who have previously reported on the microbiome, especially with respect to translational aspects. Furthermore, we will actively invite industrial partners with interests in the applied microbiome to attend; this may open the door to

recruitment of industrial sponsorships for the meeting. Furthermore, if funded, the College of Agriculture and Departments of Food Science, Agricultural and Biological Engineering, Animal Science, and Entomology have agreed to cost-share the proposed conference to extend the reach of investments by the CRS (reflected in budget below).

Microbiome management and engineering has also been deemed of interest to NIH (Lita Proctor, director of the HMP, and Linda Duffy, NCCIH/Trans-NIH Microbiome Working Group), USDA (David Klurfeld, Nutrition, Food Safety/Quality) and Department of Energy (Todd Anderson, Office of Biological and Environmental Research). Successful execution of an internally-funded symposium would provide strong impetus for an NIH R13 Support for Scientific Conferences grant, as it would display to NIH 1) Purdue's leadership in microbiome management and engineering and broad academic interest. After an initial year of Provost support, we will write R13 proposals for subsequent years to convert the event into a recurring (hopefully annual) meeting hosted at Purdue.

We propose the symposium proceedings be coalesced into a publication to be submitted as an editorial or perspective piece, potentially to *ISME J*, the journal of the International Society for Microbial Ecology and one of the highest-ranked journals in both microbiology and ecology (2016 impact factor: 9.664), or potentially to a broad-interest journal such as *Nature* or *Science*. This piece would extend the impact of the symposium beyond those able to participate in person, and formally define the field of microbiome management and engineering.

Possible Linkages to Professional Associations: American Society for Microbiology,
International Society for Microbial Ecology

Proposed Budget: