14th Annual Microbial Sciences Symposium

April 15, 2017
Lecture Hall “C”
Science Center
Harvard University
Cambridge, MA

Microbial Sciences Initiative at Harvard
Introduction

Today’s Symposium has been organized by the Microbial Sciences Initiative (MSI) at Harvard University. MSI is an interdisciplinary science program aimed at a comprehensive understanding of the richest biological reservoir of the planet, the microbial world. Microbes are ubiquitous and have an impact on every aspect of our existence. Yet, their intrinsic invisibility has meant that they have remained largely unknown, their effects and enormous potential often unrecognized. The recent realization of the vastness of microbial diversity and the genomics revolution have propelled the microbial sciences into an exciting new era of investigation.

MSI is playing a key role in this emerging area by serving as an organizational focal point for microbial studies with strong links to already existing science departments and schools at Harvard. MSI encourages broad interactions among microbial scientists across the Boston area and connects work on microbial sciences to ongoing work in related areas including molecular biology, medicine, biogeochemistry, evolutionary biology, and environmental engineering. Thus, MSI is a community across the entire University including students, postdoctoral fellows, and faculty.

MSI supports a variety of activities that foster interdisciplinary research, including colloquia, seminars, and weekly discussions of microbial science issues. Additionally, MSI runs several programs for students, such as a graduate consortium and, for undergraduates, a summer fellowship program and a secondary field. Further, the MSI has played a key role in the recruitment of several new faculty.

It is our hope that this Symposium will, by presenting some of the breadth and depth of microbial sciences today, stimulate discussion among members of our scientific community that will help strengthen this integrative science initiative. We thank you for your attendance and welcome you to today’s activities.
Opening Remarks and Welcome

Session I

David Nelson
Harvard Faculty of Arts and Sciences, Dept. of Physics, Dept. of Molecular and Cellular Biology
Harvard School of Engineering and Applied Sciences
“Range expansions in structured environments”

Cammie Lesser
Harvard Medical School, Dept. of Medicine, Massachusetts General Hospital
“Bacterial delivery systems from agents of pathogenesis to vectors for novel therapeutics”

Coffee Break

Session II

Dan Distel
Northeastern University, Ocean Genome Legacy Center
“Firewood and brimstone: from xylotrophic to thioautotrophic symbiosis in shipworms”

Carrie Harwood
University of Washington School of Medicine, Dept. of Microbiology
“Bacterial longevity”
Lunch
12:00 - 2:00

Session III
2:00 - 3:20

Katharina Ribbeck
Massachusetts Institute of Technology, Dept. of Biological Engineering
“Probing microbial interactions with the mucus barrier”

Bill Hanage
Harvard T.H. Chan School of Public Health, Dept. of Epidemiology
“The golden age of bacterial population genomics”

Coffee Break
3:20 - 3:40

Session IV
3:40 - 5:00

Rachel Carmody
Harvard Faculty of Arts and Sciences, Dept. of Human Evolutionary Biology
“Partners in chyme: dietary manipulation of the gut microbiome”

Pete Greenberg
University of Washington School of Medicine, Dept. of Microbiology
“Sociomicrobiology: bacteria quorum sensing, cooperation and conflict”

Closing Remarks

Reception
David Nelson
Professor
Departments of Physics, Molecular and Cellular Biology
Harvard Faculty of Arts and Sciences, Harvard School of Engineering and Applied Sciences

Education:
A.B. Cornell University
Ph.D. Cornell University

Selected Honors and Awards:
• Member of the National Academy of Sciences
• Member of the American Academy of Arts and Sciences
• Bardeen Prize
• Buckley Prize
• MacArthur Prize Fellowship

Research Interests:
David Nelson was trained in condensed matter theoretical physics, where his science for 25 years focused on defect-mediated phase transitions, turbulence, geometrical frustration metallic glasses, the statistical mechanics of flexible sheet polymers and vortex physics in high temperature superconductors. However, much of his research over the past two decades has focused on problems that bridge the gap between the physical and biological sciences. His more recent interests include single molecule biophysics and the statistical mechanics of force-induced unzipping transitions in polynucleotides, the buckling transition triggered by 5-fold symmetric defects in viral capsids with an icosahedral symmetry, genetic demixing, spatial population genetics and range expansions in microorganisms, defect-mediated growth of bacterial cell walls and localization in non-Hermitian neural networks.
Cammie Lesser  
Associate Professor  
Department of Medicine  
Harvard Medical School, Massachusetts General Hospital

Education:  
Sc.B. Brown University  
Ph.D., M.D. University of California at San Francisco

Selected Honors and Awards:  
• MGH d’Arbeloff Research Scholar  
• NIH Transformative Research Award  
• NIH EUREKA Award  
• Charles E. Culpeper Scholar

Research Interests:  
The Lesser lab is interested in understanding how bacterial pathogens manipulate host cell processes to promote their own survival and replication during the course of an infection. In particular, their efforts focus on determining how bacterial factors injected via type 3 protein delivery systems into the host cell cytosol act to disarm host innate immune responses, including the induction of pro-inflammatory cytokine production, pyroptosis and autophagy. Their studies focus on studying virulence factors from Gram-negative enteric pathogens that cause gastrointestinal diseases including Shigella, Salmonella, Yersinia and enteropathogenic E. coli. The group has developed multiple innovative technologies to address these questions including an innovative bottom-up approach to study single, potentially functionally redundant effectors as well as yeast functional genomic and proteomic approaches to identify conserved eukaryotic signaling pathways targeted by the virulence proteins. More recently, the Lesser lab has begun to exploit findings garnered from mechanistic based studies to develop bacterial strains engineered to secrete proteins of therapeutic value into host cells or the intestinal lumen.
Dan Distel
Research Professor
Ocean Genome Legacy Center
Northeastern University

Education:
B.S. Rutgers University
Ph.D. University of California at San Diego

Research Interests:
Distel’s career has focused on the diversity of marine life and the processes that create and sustain this remarkable diversity. One of these diversity drivers is symbiosis: the integrated coexistence of different species. Through competitive and cooperative interactions, symbiotically coexisting species create new functionalities and new niches that mold the evolution of the symbiotic partners. The focus of much of his research has been on the composition, function and evolution of symbiotic interactions between bacteria and marine animals. These symbioses are virtually universal, as few if any marine animals are devoid of microbial partnerships. The results of symbiosis can be quite fantastic. For example, through symbiotic associations with bacteria that live inside their cells, some animals have gained the ability to feed on bizarre dietary items including natural gas, hydrogen sulfide, and wood. Such symbioses are powerful model systems for studying co-evolution, mechanisms of infection, and processes of energy metabolism.
Carrie Harwood  
Professor  
Department of Microbiology  
University of Washington School of Medicine

**Education:**  
B.S. Colby College  
Ph.D. University of Massachusetts

**Selected Honors and Awards:**  
- Member of the National Academy of Sciences  
- Member of the American Association for the Advancement of Sciences  
- Member of the American Academy of Microbiology  
- Procter & Gamble Award in Applied and Environmental Microbiology

**Research Interests:**  
The Harwood laboratory is interested in understanding how bacteria integrate diverse environmental signals and diverse metabolic modules to function at the whole cell level. The researchers rely heavily on genome sequencing, mutant construction and analysis and transcriptome analysis for their work. One major area of interest is bioenergy production. Utilizing the model organism *Rhodopseudomonas palustris* (Rpal), they study bacterial mechanisms of long-term survival and regulation of photosynthesis. Rpal stays alive for periods of months in a starved non-growing state as long as it is provided with light. Their goal is to generate foundational knowledge that will improve the ability to use non-growing photosynthetic bacteria as biocatalysts to convert inexpensive feedstock compounds to hydrogen gas or other biofuels. Towards this end they are trying to: 1) understand signal transduction cascades involved in the regulation of photosynthesis at low light and 2) define genes that are important for long term survival of non-growing cells. A second major area of inquiry is novel quorum sensing signals, bacterial cell-to-cell communication, and signaling between bacteria and the plant Populus.
Katharina Ribbeck  
Associate Professor  
Department of Biological Engineering  
Massachusetts Institute of Technology

**Education:**  
B.S. University of Heidelberg  
Ph.D. University of Heidelberg

**Selected Honors and Awards:**  
- Harold E. Edgerton Faculty Achievement Award  
- NSF Career Award  
- The Junior Bose Award for Excellence in Teaching  
- *Popular Science* Brilliant Ten Award

**Research Interests:**  
The Ribbeck lab’s focus is on basic mechanisms by which mucus barriers exclude, or allow passage of different molecules and pathogens, and the mechanisms pathogens have evolved to penetrate mucus barriers. It hopes to provide the foundation for a theoretical framework that captures general principles governing selectivity in mucus, and likely other biological hydrogels such as the extracellular matrix, and bacterial biofilms. The Lab’s work may also be the basis for the reconstitution of synthetic gels that mimic the basic selective properties of biological gels.
Bill Hanage  
Associate Professor  
Department of Epidemiology  
Harvard T.H. Chan School of Public Health  

Education:  
B.S. University of Bath  
Ph.D. Imperial College London  

Selected Honors and Awards:  
• Fleming Prize  
• ASM’s ICAAC Young Investigator Award  
• Royal Society University Research Fellow  

Research Interests:  
Bacterial populations exhibit varying degrees of genetic diversity, some being almost completely uniform while others are a riot of different clones, each characterized by different combinations of mutations and genes. The goal of the Hanage lab is to understand the evolutionary pressures that produce this observed variation, and to link it to transmission, virulence or other traits such as drug resistance. This means looking at how variation arises over different evolutionary timescales, from the origins of bacterial species to the very recent transmission that occurs in outbreaks. This perspective is informed by working on many different species, with the goal of finding general patterns. We can now rapidly and economically determine genome sequences for hundreds or thousands of bacterial isolates, and members of the lab work to combine this information with mathematical and computational models of evolution, to understand how the pathogen populations we see have come to be. The hope is that by better understanding what has happened in the past, we can better intervene in the future to limit the burden of infection.
**Rachel Carmody**  
Assistant Professor  
Department of Human Evolutionary Biology  
Harvard Faculty of Arts and Sciences  

**Education:**  
B.A. Harvard University  
Ph.D. Harvard University  

**Selected Honors and Awards:**  
- NIH Ruth L. Kirschstein National Research Service Award  
- NSF Graduate Research Fellowship  
- Thomas Temple Hoopes Prize  

**Research Interests:**  
Dr. Carmody seeks to understand how the human body acquires and utilizes energy, and how past changes in energy budget have shaped human evolution. Within the past decade, it has become clear that energy metabolism depends on complex interactions between diet, health, genetics, and the structure and function of the microbial communities living inside the human body. Her work considers the human body as an ecosystem, integrating perspectives and experimental techniques from evolutionary biology, nutrition, physiology, microbiology, and metagenomics to pursue a richer understanding of energy exchange. Currently, the Carmody group is employing this ecosystem approach to probe the digestive capacities that are unique to humans, host-microbial cooperation and conflict over energetic resources, and the caloric potential of non-caloric dietary components.
Pete Greenberg
Professor
Department of Microbiology
University of Washington School of Medicine

Education:
B.A. Western Washington University
Ph.D. University of Massachusetts

Selected Honors and Awards:
• Member of the National Academy of Sciences
• Member of the American Academy of Arts and Sciences
• Member of the American Association for the Advancement of Sciences
• Shaw Prize in Life Sciences

Research Interests:
The research in Dr. Greenberg’s laboratory is focused on the emerging field of sociomicrobiology. He is principally concerned with the phenomenon of bacterial quorum sensing and its involvement in aspects of sociomicrobiology: He studies the biochemistry and molecular biology of quorum sensing, the diversity of quorum sensing signaling systems in Proteobacteria, and quorum sensing control of cooperation in bacterial populations. Dr. Greenberg began his work on bacterial communication as a Harvard Postdoctoral Fellow where he worked on luminescent marine vibrios. For the past 25 years he has concentrated much of his effort on Pseudomonas aeruginosa, an opportunistic pathogenic bacterium that can cause both acute and persistent biofilm infections. Recent work has focused on how bacteria stabilize cooperation via co-regulation of genes by the quorum sensing circuitry. His research team has uncovered molecular mechanisms for policing of uncooperative defectors and metabolic restraints on defectors. The Greenberg lab has identified regulatory elements that define commitment steps in development of biofilms and these serve as targets for novel antibiofilm therapeutic development.