

American Association for the Advancement of Science

**Report on the AAAS Microbiomes of the
Built Environment Symposium, Spring 2014
Funded by the Alfred P. Sloan Foundation**

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Report on the AAAS Microbiomes of the Built Environment Symposium, March 27th, 2014, funded by the Alfred P. Sloan Foundation

Executive Summary

The research field of Microbiomes of the Built Environment (MoBE) is relatively new, evolving about ten years ago from the discovery that humans are exposed to tremendous numbers and diverse species of bacteria, viruses, fungi, and protozoa inside the environments that we build. All built environments, including homes, offices, airplanes, and more, contain these microbial communities, or “microbiomes.” These microbiomes affect our structures through mold and corrosion, as well as influence our health both positively and negatively. As a result, understanding what microorganisms are present and how they behave in this ecosystem is critically important not only for human health, but for how we design and interact with the built environment.

Through its [Microbiology of the Built Environment Program](#), the Alfred P. Sloan Foundation (the Sloan Foundation) has taken a leadership role by catalyzing a community of researchers, supporting over 50 distinct research projects since 2005. The Sloan Foundation recently awarded the American Association for the Advancement of Science’s (AAAS) [Research Competitiveness Program](#) (RCP) a grant to hold a one-day symposium in order to present MoBE research to federal agencies and other stakeholders. RCP organized this symposium, conducted on March 27th, 2014, at the AAAS headquarters in Washington, D.C., in close proximity to federal agencies and nonprofit associations. The symposium had two goals: 1) to showcase the diversity and impact of the research supported by the Sloan Foundation’s MoBE Program, as well as other research in the field; and 2) to create a dialogue among the researchers and the broader stakeholder community.

In consultation with the Sloan Foundation, RCP selected 20 speakers and moderators representing a breadth of topics and approaches critical to federal agencies, nonprofit associations, and industry. Topic coverage via four panels focused on: 1) The science and diversity of MoBE research; 2) differences among microbiomes and their impact on infrastructure; 3) their impact on human health; and 4) the use of this knowledge to manage building design, energy efficiency, biosecurity, and more. A final panel then presented an overview and discussed next steps and research needs. Also to promote discussion with attendees, the agenda included Q&A sessions, long networking breaks, and an evening reception.

To determine who to invite, RCP conducted a stakeholder analysis based on the potential impacts of the field. We then contacted the various organizations directly to gauge interest, which was strong with almost 50% of those contacted replying and/or registering. This stakeholder audience remained the main focus until one month before the symposium, after which remaining space was opened to wider groups like the Federal Green Building listserv, and then to the broad AAAS community. As a number of federal attendees could not travel to the symposium, RCP further decided to both livestream and video-record the event, and created a hashtag #aaasmobe to support tweeting. RCP also coordinated with the AAAS Office of Government Relations to present a Capitol Hill briefing by three of the symposium’s speakers, who emphasized topics on infrastructure and human health. This briefing was video-recorded as well and each talk is available online. Finally, three weeks after the symposium, RCP conducted

separate surveys of the speakers and attendees to determine the symposium's impact and potential next steps of the field.

More than 85 individuals representing 50 agencies and organizations attended the symposium. In addition, over 50 participants accessed the symposium via a live webcast, and 30 registered for the Hill briefing. The online videos of the symposium have now reached almost 300 views and continue to be accessed daily (numbers for the videos of the Hill briefing are not available). As tweeting of the symposium was very active, one of the speakers, Dr. Jonathan Eisen, also created an archive of the tweets that has since been widely viewed.

Besides the introduction of this new field to the audience and the clear presentation of its impacts, the symposium has led to several actions, including: 1) 90% of the attendees have recommended that colleagues learn more about the MoBE, according to the survey; 2) two news stories were published; and 3) approximately 60% of symposium participants are pursuing contacts made during the event. Also, one of the major outcomes of this symposium and the main reason for this report is the compilation of needed actions discussed among the speakers and attendees during the event. These needs included: research tools and methods; communication; microbiome, building, and health-focused research; research at the intersection of MoBE and health, and research towards applications.

As noted by the speakers and many of the attendees of the symposium, the MoBE field is critically important in our globally connected world. AAAS and the RCP are very pleased to have been involved in the event's organization, especially in helping create a continuing dialogue among the leading MoBE researchers and stakeholders. AAAS looks forward to engaging with this community as it continues to grow and evolve.

Report on the AAAS Microbiomes of the Built Environment Symposium, March 27th, 2014, funded by the Alfred P. Sloan Foundation

Introduction

This report presents the accomplishments of the AAAS Microbiomes of the Built Environment Symposium, funded by the Alfred P. Sloan Foundation (The Sloan Foundation). The Sloan Foundation awarded the [Research Competitiveness Program](#) (RCP) of the American Association for the Advancement of Science (AAAS) a grant to hold a one-day symposium in 2013 that would present research on the microbiomes of the built environment (MoBE) to federal agencies and other stakeholders. AAAS organized this symposium at its headquarters in Washington, D.C., in close proximity to federal agencies and nonprofit associations to achieve two goals: 1) showcase the diversity and impact of the research supported by the Sloan Foundation's Microbiology of the Built Environment Program, as well as other supporters of the field; and 2) engage researchers and any potential funders and applicators of this research in a dialogue of future directions and needs.

The AAAS Microbiomes of the Built Environment Symposium was originally proposed for late spring 2013, with, October 7th, 2013 chosen as the best date due to speaker schedules. Unfortunately, the 2013 Federal Government shutdown one week before the symposium prevented approximately 15% of the speakers and moderators, and almost half of the attendees from participating. In response, the Sloan Foundation and AAAS jointly decided to postpone the symposium, which was rescheduled for March 27th, 2014.

More than 85 individuals representing 50 agencies and organizations attended the symposium onsite, and over 50 participants participated via a live webcast. These and other outcomes are described more below.

Background

The research field of MoBE is relatively new, evolving from Sloan-funded work in the biosecurity arena around ten years ago. Central to the core of this field was the discovery that humans, who spend 90% of their time indoors¹, are exposed to tremendous numbers and diverse species of bacteria, viruses, fungi, and protozoa in the air, in water systems, and on surfaces inside the environments that we build. All built environments contain these microbial communities, or "microbiomes:" houses, offices, retail stores, public buildings, hospitals, modes of transportation and more. Microbiomes affect our structures through mold and corrosion and influence our health, both positively and negatively. In addition, this exposure is dynamic, influenced by such factors as air flow, temperature, humidity, and building materials.

As a result, understanding what microorganisms are present, what they are doing, and how they behave in this ecosystem is exceptionally challenging but critically important, not only for human health, but for

¹ Klepeis et al., *Journal of Exposure Analysis and Environmental Epidemiology* (2001) 11, 231-252, sponsored by the U.S. Environmental Protection Agency.

how we conceive, design, and interact with the built environment. Through its [Microbiology of the Built Environment Program](#), the Sloan Foundation has taken a leadership role by catalyzing a community of researchers, with over 50 distinct research projects supported since 2005.

In 2012, the Sloan Foundation sought to share this research with a much wider audience. It requested the assistance of AAAS in order to benefit from the convening power and prestige of the world's largest general scientific society. The [RCP](#), a unit of the AAAS Center of Science, Policy and Society Programs (CSPSP), mobilizes the intellectual resources of American science, engineering and technology policy communities to improve research, development, and innovation practices; it led the AAAS efforts to organize the symposium.

Goals and Objectives

As noted in the introduction, the two main goals of the symposium were to showcase the diversity and impact of research in this field and to create a dialogue between the researchers and other stakeholders. In further discussions with the Sloan Foundation, these key objectives were determined:

1. Introduce this new field to federal agencies, nonprofit associations, foundations, scientific associations and the private sector. Notably, the emphasis for this symposium was not to convene the broad field of researchers in a scientific dialogue.

2. Design the agenda to present a range of topical areas that resonate with different stakeholders.

Topics include the relationship of microbiomes to:

- Building design and environmental control
- Drinking water and wastewater infrastructure
- Human health
- Transportation, including airplanes
- Biosecurity

3. Emphasize through the presentations the field's potential, as well as the needs of the research community.

4. Promote abundant, unscripted dialogues between the research community and other stakeholders.

5. Help create a broader community with interest in continuing or applying the research.

Methods

Dr. Mark Milutinovich, Director of the RCP, is the Principal Investigator for the grant and served as the AAAS point of contact for the Sloan Foundation. He was assisted by Dr. Annette Olson, Senior Program Associate with the RCP; Bethany Spencer, Directorate/Project Administrator with the AAAS Center of Science, Policy, and Society Programs; Benjamin Somers, Program Operations Coordinator with the RCP, and additional AAAS scientific, technical and support staff.

Agenda

Twenty speakers and moderators were selected who represented a breadth of topics and approaches critical to federal agencies and other organizations. Topic coverage focused on four panels: 1) The science and diversity of MoBE research; 2) differences among microbiomes and their impact on infrastructure; 3) their impact on human health; and 4) the use of this knowledge to manage building design, energy efficiency, and more. Each topical area included three research talks and a knowledgeable moderator to stimulate audience Q&A. A final panel then presented an overview and discussed next steps and research needs. Also, to promote dialogues among attendees, the agenda included: a) question and answer sessions at the end of each panel; b) 30-minute breaks between most panels; and c) an evening reception. See Appendix 1 for the final agenda.

Attendees

RCP conducted a stakeholder analysis of organizations working in the intersection of building science, human health, and microbiology, including government agencies, associations, industry, foundations, and others. RCP then directly contacted each organization to gauge interest and availability for the symposium. This stakeholder audience remained the main focus until one month before the symposium, after which remaining space in the auditorium was opened to the broader AAAS community.

The Registration Website and External Communications

AAAS developed several means for promoting and disseminating the symposium to the intended audience. A website (<http://events.signup4.com/microbiomes>) was created after the agenda was finalized in late July, 2013, to communicate the purpose, agenda, location, and logistics associated with the symposium, as well as to provide a site for attendees to register. This site was again used for these purposes in 2014. Once it became clear that a number of invitees would not be able to attend due to restrictions on federal travel, RCP decided to also livestream and video-record the event. A webcast site on the AAAS servers (www.aaas.org/microbiomes) was created; this site remains available and shows the video-recordings of the symposium. During the symposium itself, AAAS encouraged chats among and questions by the online audience. It also encouraged Twitter participation with the tag #aaasmobe.

In addition, RCP coordinated with the AAAS Office of Government Relations to present a briefing on Capitol Hill the day before the symposium. This event was not covered under the Sloan Foundation grant, and was run separately by AAAS at its own expense. Three of the symposium's speakers were invited (see Appendix 3 for the invitation), with the emphasis on infrastructure and human health topics, especially on water infrastructure and hospitals. AAAS also video-recorded the briefing (<http://membercentral.aaas.org/multimedia/videos>)

After the symposium, AAAS created two separate surveys; one sent to the attendees, and one to the speakers and moderators. These surveys were sent out three weeks after the symposium to get feedback on the content of the symposium and on next steps, as well as to determine the symposium's impact, especially whether attendees had already taken steps towards creating collaborations.

Symposium Support

In addition to monitoring and updating the registration website, Ms. Spencer coordinated hotel blocks and flights for invited speakers, and arranged for catered meals during the symposium. RCP staff members were also available onsite during the symposium to assist with logistics and answer questions.

The Outcomes – Impact of the Symposium

Goal 1: Showcasing this Diverse Topic to New Audience

The introduction of MoBE to new audiences is presented by the method: invitation, social media and PR, survey, and a Hill briefing.

Invitations

RCP contacted 444 individuals in over 200 organizations, and strong interest was apparent:

1. Approximately 85 people attended the symposium at the AAAS headquarters, with 74 of those outside of AAAS or the Sloan Foundation, representing 50 organizations, including 12 federal agencies, 14 associations, industry, foundations, and universities. (Appendix 2).
2. Throughout the day, the numbers of attendees via the webcast ranged from 51 to 60. As RCP did not register webcast attendees, most remain unidentified. Those who self-identified using the Livestream chat or via Twitter included federal employees and several microbiology researchers.
3. Sixty people had expressed strong interest in attending the symposium in house, either by registering in 2013 or 2014 or by stating that they planned to attend, but in the end were not able to be present in person. It is not known how many people were able to join via the livestream. (Thirteen of the 60 had expressed interest in any presentations placed online after the symposium.)
4. An additional 63 replied to the invitation via an email stating they couldn't make it, with many of them noting they wished they could. These repliers represent the minimum number of remaining invitees exposed to a description of MoBE.

Social Media and PR

Social media helped encourage high participation and brought new audiences to the subject of MoBE.

1. The [webcast's](#) audience members asked questions and discussed points and further spread word about the symposium by tweeting the webcast site directly to others at least 100 times, and liking the site on Facebook 24 times.
2. Though it is over a month since the symposium, at least 2-7 viewers watch the videos daily on the webcast site, and 173 - 282 views have been recorded so far for the 5 different panel sessions. A portion of these views likely reflect speakers or those who attended previously, but the remaining would comprise a new audience.
3. Twitter participation was constant and active during the symposium itself, reaching additional parties as far away as Spain and Italy. One of the speakers, Dr. Jonathan Eisen, later pulled together

all the video, resources, and Twitter feed into a “Storify,” where the conversation during the event can still be viewed.

http://microbe.net/2014/03/29/storify-of-tweets-background-videos-from-aaasmobe-meeting-on-microbiomes-of-the-built-environment/?utm_source=twitterfeed&utm_medium=twitter

According to the website, the Storify has been viewed over 12,263 times, although we are not able to confirm that this number can be interpreted as views of this particular Storify. However, numerous tweets can be summed up as follows: “Many thanks to #AAASMoBE tweeters. A totally awesome stream of indoor #microbiome information, ickiness, and insights,” C. Torgan.

Finally, although outside press exposure had been limited, two news stories were published.

1. *Gizmodo*:

<http://gizmodo.com/concrete-dissolving-bacteria-are-destroying-our-nation-1553419185>

2. *Science News*:

<http://www.aaas.org/news/sewers-streetlights-microbes-are-grabbing-civil-engineers-attention>

Survey results

The survey’s results for attendees and for the speakers indicated the symposium’s success in showcasing the diverse topics of MoBE to a new audience. The survey for the attendees went out to 71 participants besides AAAS and Sloan staff. Twenty-one replied, a return of 30%, higher than anticipated. Taking into consideration the likelihood that the people who respond to surveys about conferences are probably weighted towards either being satisfied or unsatisfied, here are some responses:

1. Eighty-five percent of the respondents were ‘very satisfied’ with the symposium, while the remaining 15% were ‘somewhat satisfied.’ Comments included: “I achieved my goal and the meeting was well organized,” “the information was fascinating!” and “really superb talks.”
2. Five respondents noted that one of the most beneficial aspects of the conference was the diversity of participation, for instance in “seeing the diversity of the field and getting a chance to talk with others from very different backgrounds.”
3. The survey indicated that 90% (18 participants) had already recommended that colleagues learn more about the MoBE. One comment also included: “I’m seen as a resource by colleagues who didn’t know about this.”

For the survey that went out to the speakers and moderators, nine replied, a return of 43%. At least two speakers were pleased that the audience appeared engaged, and several themselves also appreciated the diversity of the presentations.

Briefing on Capitol Hill

Thirty people registered for the Hill briefing, with at least six being Congressional staffers. The three talks were videotaped, and are available on AAAS Member Central for viewing.

<http://membercentral.aaas.org/multimedia/videos/microbiologist-diverse-microbial-communities-good-human-health>

<http://membercentral.aaas.org/multimedia/videos/microbiome-research-could-ward-antibiotic-resistance>

<http://membercentral.aaas.org/multimedia/videos/microbes-eating-away-nations-sewer-systems>

The number of views, tweets, and likes are not available online for these videos.

Goal 2: Creating a Dialogue among Researchers and Other Stakeholders

The symposium agenda was designed to encourage dialogue. Attendee survey responses indicated that the agenda structure provided the hoped-for opportunities for discussion – though even more time for discussion/networking was desired. Comments included: “Open exchange of information in an environment conducive to interaction;” “Very engaged speakers and participants, lots of networking opportunities;” and “...a wonderful collaboration.” In the speakers’ survey, several speakers and moderators also noted that one of the most beneficial aspects of the conference was the conversations during the breaks, but also wished there had been more networking opportunities.

The symposium resulted further in formal contacts being made:

1. Of the 21 attendees who responded, 95% percent (19) said they made contacts during the symposium, and 58% (11) said that they had already followed through in communicating with these people.
2. Of the nine speakers and moderators who responded, eight said they made contacts during the symposium, and six said they had already contacted them.

Another indication of the dialogue developing from this symposium is one attendee’s request for RCP to forward on to the MoBE community: a representative of the American Planning Association said that she wants her organization to “very much...have a place at the table” in future workshops and discussions. Finally, another commenter stated in the survey under ‘other impacts from this symposium,’ that (s)he is “exploring integrating microbiomes into communications planning.”

Additional Outcomes: Next Steps

The last panel of the symposium brought together six of the earlier speakers, with Dr. Richard Corsi, University of Texas, serving as the moderator, to discuss the state of the field and the future. Dr. Corsi commented on the importance of buildings in our lives; we spend more time indoors than whales spend in the ocean proportionally. In addition to discussing the specifics of building ventilation design and their repercussions on indoor microbial activity, Dr. Corsi asked the panelists, “What are the top research needs in the microbiome field over the next five years?” The responses ranged from tools, to research, to communication, to application. The audience Q&A session and the attendee and speaker surveys also provided opportunities to comment on proposed next steps. The resulting list of stated needs is below.

P = Panel suggestion, A = audience suggestion, SS = speaker survey, AS = attendee survey. Any number following is the number of times a need was mentioned across the discussion or surveys.

Research Tools and Methods

1. Model organisms/systems set up by multidisciplinary teams, incl. architectural and building scientists (P)
2. Better measurement and analytical tools (P, AS)
3. Standards in MoBE sampling, sequencing and data processing, data consistency (P, AS-4, SS)
4. Data quality (AS)
5. Ways of linking different academic fields in the data (e.g., architecture and biology) (P)
6. More specificity in our research (P)/Resolution and direction on what to measure (P)/ Learn the parameters of the question before getting into applications for building design (P)

Communication

7. Greater collaborations across disciplines (e.g., microbiology, engineers, health person), forum for consensus building and for standardization. (P-2, SS)
8. Greater connection to mainstream concern, practical goals (A-2)
9. Greater public concern and understanding (P)
10. Political will on microbial issues (P)
11. Enhanced educational efforts (P), especially for building scientists and engineers (SS)
12. Training of the next generation of multidisciplinary practitioners, e.g., NIOSH ERC training models (A, P)

Microbiome/microbial-oriented research

13. Change in microbiomes over time
14. Microbial ecology (AS-2)
15. Microbe quorum sensing and signaling, and the consequences of intervening in that. (P)
16. Examine fungi more, not just bacteria (SS, AS)
17. Species level analysis (AS)
18. The characteristics (and durability) of DNA outside a cell, (SS)

Building-oriented Research

19. Dig deeper into building anatomies, building science (P, AS, SS)
20. The influence of built environments on microbiomes/transmission within a built environment/ building, airflow patterns (AS-2, SS)
21. Smart methods and materials that are not human driven, to decrease human factors in environmental control (P)
22. The interaction of microbiomes with building materials, the interface, surfaces (P-2, AS)
23. Retrofitting/renovation (AS-2)
24. Wider community/city systems such as water infrastructure (AS-2)
25. How is the built environment going to change in response to global climate change (P) /impact of energy-efficient buildings (P)

Health-oriented Research

26. A better understanding of microbiomes and human health at various ages (P-2, SS, AS-5); the definition of normal, human health (AS),
27. Immunology (A, AS), probiotics (AS)
28. Influence on atopic diseases (AS)
29. Environmental epidemiology (SS, AS)
30. Agriculture and gut microbiomes (AS)
31. Determine the mode of transmission of influenza, as we still don't have an answer (P)

Intersection of MoBE and health

32. General intersection of microbes and built environments and health (AS-2)
33. Determine what is a normal hospital water system, a healthy microbial community in the home (AS-2)
34. How MoBEs change with incidence of infectious disease/how do personal microbiomes interact with building microbiomes of the ill (SS,AS)
35. Value of biological diversity in buildings towards human health (plants, pets)(AS)
36. Chemicals' potential impact on the relationship between microbiology and human health (chemicals in buildings, in our bodies.) – finding the balance. (A; SS)
37. How MoBEs will respond to climate change and new building design and their impact on human health. (P)

Research towards Applications

38. The design of potential new microbiome research equipment (SS)
39. Better (healthier) buildings – construct, operate, and maintain (P, SS), best practices (AS-5)
40. Indoor Air quality (AS)
41. Need to make hospitals into safer environments and better prepare for epidemics. (P)
42. How design changes to manage pathogenic organisms affect the microbiome (P)
43. Target pathogens without dramatically impacting environment (P)
44. Forensics (AS)
45. How microbes influence occupant behavior and experience (AS)
46. Better water treatment (P-3, AS)/Grey water use (P)
47. Impact on storage and transport of water, infrastructure design (P-2)
48. Better building materials (P), and
49. Remediation (P, AS)

Tools for Application

50. Monitors of effectiveness after internal environmental procedures (P)

The speakers and the attendees differed somewhat as to how to remain informed of the latest news in the field. The primary way that the speakers wanted to share the latest information was by having symposia at other conferences. The attendees primarily wanted to learn the latest information in microbiomes through a follow-on symposium, though 'symposia at other conferences' was their second choice. The different leanings may reflect that: 1) many government agencies are more likely to be able to attend a one-day local conference focused on a specific topic, than larger conferences; and 2) the speakers may want to continue to help introduce this topic to new audiences accessible via conferences with broad subject coverage. However, a common comment within the attendees' survey regarded the hope that the momentum from the symposium would continue.

Conclusion

The symposium achieved the goals set out in the proposal, and AAAS and the RCP are pleased to have been involved in the event's organization, especially in helping create a continuing dialogue among leading MoBE researchers, funders, and the experts for the field's potential application. We appreciate the support from the Sloan Foundation and are particularly grateful for the assistance of Paula Olsiewski, whose tireless input was critical to the success of the symposium. The MoBE field is critically important in our globally connected world. The discussions during the symposium clearly outlined the far reaching impacts of the research being conducted, and the research yet to be done. AAAS looks forward to engaging with this community as it continues to grow and evolve and will look for further opportunities to contribute to its success.

Appendix 1: Agenda

AAAS Symposium on the Microbiomes in the Built Environment

Sponsored by the Alfred P. Sloan Foundation

#aaasmobe

March 27th, 2014

AAAS Headquarters,

1200 New York Avenue, NW
Entrance at 12th and H Streets

Washington, DC,

8:15 – 8:45 A.M. **Coffee, Check-in, and Networking.** *2nd floor Mezzanine*

8:45 – 9:00 A.M. **Welcome and Introduction.** *Auditorium.*

Edward Derrick, Ph.D.; Chief Program Director, Center of Science, Policy and Society Programs,
American Association for the Advancement of Science

Paula J. Olsiewski, Ph.D.; Program Director, Alfred P. Sloan Foundation.

9:00 – 9:30 A.M. **Plenary: *Microbiomes and Worker Health: The Need for More Research.***

John Howard, M.D., M.P.H., J.D., LL.M.; Director, National Institute for Occupational Safety and
Health; Administrator, World Trade Center Health Program, CDC

9:30 – 10:30 A.M. **Panel 1: Indoor Microbiomes: the Diverse Microbial Communities Existing within
our Buildings, Auditorium.**

Moderator: **Donald Milton**, Dr.P.H; Professor and Director, Maryland Institute for Applied
Environmental Health, University of Maryland School of Public Health, College Park, and
Professor of Medicine, University of Maryland School of Medicine, Baltimore

*The Recent Field of Microbiomes of the Built Environment, and Potential Impacts on Building
Design and Human Health*

Jessica Green, Ph.D.; Director, Biology of the Built Environment Center, University of Oregon

Drinking Water Microbiology and the Built Environment of Water Distribution Systems

Norman Pace, Ph.D.; Distinguished Professor, Department of Molecular, Cellular and
Developmental Biology, University of Colorado

MicroBEnet: the Microbiology of the Built Environment Network

Jonathan Eisen, Ph.D.; Professor, Department of Evolution and Ecology, Department of Microbiology and Immunology, and UC Davis Genome Center, University of California, Davis

10:30 – 11:00 A.M. **Coffee and Networking Break.*** 2nd floor Mezzanine, Abelson-Haskins, Revelle, and Room 207

11:00 – 12:00 P.M. **Panel 2: How do Microbiomes Differ across Environments, and what are their Impacts?** Auditorium.

Moderator: Ryan Colker, J.D.; Director of the Consultative Council and Presidential Advisor, National Institute of Building Sciences.

Globalization of the Microbiome: Tracking Microbes in Mobile Built Environments.

Scott Kelley, Ph.D.; Professor, Department of Biology, San Diego State University

Microbially Induced Corrosion and the Accelerated Deterioration of Critical Infrastructure.

Mark Hernandez, Ph.D.; Professor, Department of Civil, Environmental, and Architectural Engineering, University of Colorado

Microbes across Human Cultures.

Maria Gloria Dominguez-Bello, Ph.D.; Professor, Department of Biology, University of Puerto Rico; New York University Langone Medical Center

12:00 – 12:45 P.M. **Lunch and Networking.** 2nd floor Mezzanine, Abelson-Haskins, Revelle, and Room 207

12:45 – 1:30 P.M. **Keynote Address:** *The International Space Station as a Microbial Observatory: Benefits for Long-duration Spaceflight and our Understanding of Microbiomes on Earth*

C. Mark Ott, Ph.D., Senior Microbiologist, Johnson Space Center, National Aeronautics and Space Administration

1:30 – 2:30 P.M. **Panel 3: Microbes and Human Health: the direct effects of these communities on our health.** Auditorium.

Moderator: **Gary Roselle**, M.D., F.A.C.P., Professor of Clinical Medicine, Division of Infectious Diseases, University of Cincinnati; Chief, Medical Service, Cincinnati Veterans Affairs Medical

Center; and Director, National Infectious Diseases Service, Veterans Affairs Central Office, Washington, DC

Overview of the NIH Human Microbiome Project

Lita Proctor, Ph.D.; Program Director, the Human Microbiome Project, National Institutes of Health

The Respiratory Effects of Dampness, Mold, and Dampness-related Agents in Buildings: What do we know? What can we do?

Mark Mendell, Ph.D., M.P.H.; Staff Scientist/Epidemiologist, Indoor Environment Group, Lawrence Berkeley National Laboratory, and Air Pollution Research Specialist, Indoor Air Quality Section, California Department of Health

Communities Enriched by the Ill: The Hospital Microbiome.

Jack Gilbert, Ph.D.; Environmental Microbiologist, Argonne National Laboratories and Assistant Professor, Department of Ecology and Evolution, University of Chicago

Major Ben Kirkup, Ph.D., Deputy Director, Department of Wound Infections, Walter Reed Army Institute of Research

2:30 – 3:00 P.M. **Coffee and Networking Break.** 2nd floor Mezzanine, Abelson-Haskins, Reville, and Room 207

3:00 – 4:00 P.M. **Panel 4: Understanding Microbial Communities in Order to Solve Environmental, Energy, Biosecurity, and Other Issues.** Auditorium.

Moderator: **Todd Anderson**, Ph.D.; Director, Biological Systems Science Division, Office of Biological & Environmental Research, Department of Energy

The Nexus of Sustainable Water Infrastructure and Public Health: Can Microbiome Research Reveal New Ways to Keep Antibiotics Working?

Amy Pruden, Ph.D., E.I.; Professor of Civil and Environmental Engineering, Virginia Tech

What Zero-energy and Prebiotic Buildings have in Common.

Jeffrey Siegel, Ph.D.; Associate Professor, Department of Civil Engineering, University of Toronto

Critical Capabilities for Biosurveillance and Monitoring Building Health

Jayne Morrow, Ph.D.; Environmental Engineer, Biochemical Science Division, National Institute of Standards and Technology

4:00 – 4:15 P.M. Break. 2nd floor Mezzanine, Abelson-Haskins, Reville, and Room 207

4:15 – 5:00 P.M. **Panel 5: State of the Field, and the Future.** *Auditorium.*

Summary – Microbiomes and Built Environments (10 mins)

Richard Corsi, Ph.D.; Chair and ECH Bantel Professor for Professional Practice, Department of Civil, Architectural and Environmental Engineering, the University of Texas at Austin.

Panel discussion on future directions (20 mins).

Moderator: Dr. Richard Corsi

Invited Panelists: Jessica Green, Norman Pace, Gary Roselle, Jeffrey Siegel,
Jayne Morrow, and Donald Milton

Open Discussion and Q&A. (15 mins)

5:00 – 7:00 P.M. Reception

* The breaks are designed to allow for maximum interaction of researchers and representatives from the stakeholder community.

Appendix 2: Attendee List

The list includes those organizations who registered for the symposium at AAAS Headquarters and picked up a badge, or who self-identified during the livestreaming of the event.

Airmid Healthgroup	MITRE
American Institute of Architects	National Academies of Sciences – Institute of Medicine, Forum on Microbial Threats
American Planning Association	National Academies of Sciences – National Research Council
American Public Transportation Foundation	National Center for Healthy Housing
American Society for Microbiology – American Academy of Microbiology	National Human Genome Research Institute
American Society for Microbiology – Biodefense Committee	National Science Foundation – Directorate for Biological Sciences
American Water Works Association	National Science Foundation – Division of Environmental Biology
Artologica	Nature
ASHRAE	TED.com
Carleton University	U.S. Department of Agriculture – Environmental Management Division
Centers for Disease Control and Prevention	U.S. Department of Agriculture – National Institute of Food and Agriculture
Centers for Disease Control and Prevention - NIOSH	U.S. Department of Defense
Centers for Disease Control and Prevention - Office of Infectious Diseases	U.S. Department of Defense – Defense Advanced Research Projects Agency (DARPA)
Centers for Disease Control and Prevention – Public Health Program	U.S. Department of Defense – Defense Threat Reduction Agency
Central Intelligence Agency	U.S. Department of Education – Green Ribbon Schools
Children's Hospital Oakland Research Institute	U.S. Department of Energy – Lawrence Berkeley National Laboratory
CNS Technologies, Inc	U.S. Department of Health and Human Services – Office for Facilities Management and Policy
Congressional Hispanic Caucus Institute - U.S. House of Representatives - Committee on Science	U.S. Department of Health and Human Services – Assistant Secretary for Preparedness and Response
Cornell University	U.S. Department of Homeland Security – Advancing Microbial Risk
Doris Duke Charitable Foundation	U.S. Environmental Protection Agency
Drexel University	U.S. Environmental Protection Agency – Office of Research and Development
Georgia Regents University	
Gizmodo	
Google	
Harvard University – Joint Center for Housing Studies	
Henry Ford Hospital's; University of Michigan	
Illinois Institute of Technology	
Intelligence Advanced Research Projects Activity	
International Academy of Indoor Air Sciences	
International Society for Indoor Air Quality	

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U.S. Environmental Protection Agency – Indoor Environments Division/Indoor Air Quality Division	University of Alberta, Canada
U.S. Environmental Protection Agency – Office of Groundwater and Drinking Water	University of California, Berkeley
U.S. General Services Administration – Office of Federal High Performance Green Buildings	University of California, San Francisco
U.S. Green Building Council	University of Chicago
U.S. National Institutes of Health - Health in Buildings Roundtable	University of Delaware
U.S. National Institutes of Health – National Institute of Allergy and Infectious Diseases	University of Maryland
U.S. National Institutes of Health – National Institute of General Medical Sciences	University of Michigan
U.S. National Institutes of Health	University of Missouri – Kansas City; Children’s Mercy Hospitals,
U.S. Naval Research Laboratory – Center for Bio/Molecular Science and Engineering	University of Oregon
	University of Pennsylvania, Philadelphia
	University of Pittsburg
	University of Texas at Austin
	University of Toronto
	Vibrant Data Labs

Appendix 3: Capitol Hill Briefing Invitation

Please join the American Association for the Advancement of Science for a public luncheon briefing entitled:

“Understanding Microbes Indoors: Impacts to Public Health, Critical Infrastructure and the Water Supply”

Wednesday, March 26, 12:00-1:30 pm
2325 Rayburn House Office Building

[*RSVP here*](#)

Tremendous numbers and diverse species of bacteria, viruses, fungi, and protozoa exist in the air, in water systems, and on surfaces, forming microbial communities or “microbiomes.” All of the environments we build contain microbiomes: houses, offices, stores, hospitals, modes of transportation, and more. Join AAAS to learn about how microbiomes exist within our hospitals, how they travel through our water supply and build resistance to antibiotics, and how they affect our country’s critical infrastructure through corrosion. Panel members will include:

-Jack Gilbert, Ph.D., Environmental Microbiologist, Argonne National Laboratories and Associate Professor, Department of Ecology and Evolution, University of Chicago

-Mark Hernandez, Ph.D., Professor, Department of Civil, Environmental, and Architectural Engineering, University of Colorado

-Amy Pruden, Ph.D., E.I., Professor of Civil and Environmental Engineering, Virginia Tech

For questions, please contact Sara Spizzirri at 202-326-6789 or sspizzir@aaas.org. AAAS is a non-profit, non-partisan organization. Since it was founded in 1848, AAAS has been dedicated to the advancement of scientific knowledge for the good of society as a whole.