MICROBIAL SYNTHESIS

Interactive data sonification for raising awareness of soil microbiome diversity in urban greenspace

Michael Mitchell
MLA 26
University of Oregon

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Project funded by the

UNIVERSITY OF OREGON'S SCHOOL OF JOURNALISM & COMMUNICATION
CENTER FOR SCIENCE COMMUNICATION
SMALL GRANT PROGRAM

In the Research Area
Producing Positive Change In Health And Health Equity

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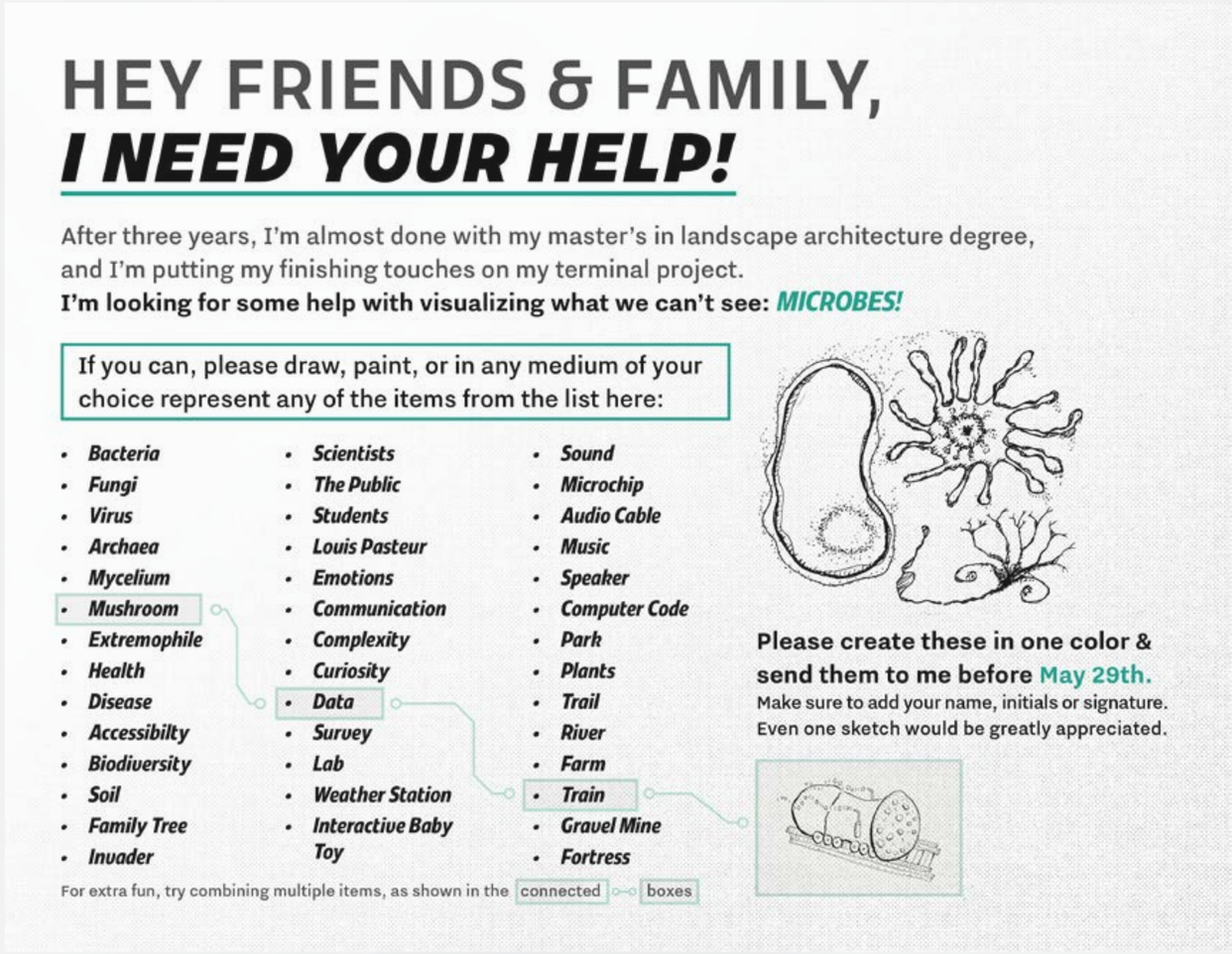
This project would not be possible without the help of the University of Oregon's School of Journalism & Communication's Center for Science Communication Research's (SCR) Small Grant program. Thanks to their financial support, my MLA terminal project, *Microbial Synthesis*, was able to go from an idea to reality. Landscape Architecture is at its core a discipline of communication, and aligns well with SCR, who, "... makes science useful by exploring how to share discoveries with the public. Through research, education, and outreach, we enhance the conversation between scientists and society"[1] SCR's Small Grant program provides funding for faculty and students at University of Oregon who are interested in researching science communication that relates to one of their four key areas. *Microbial Synthesis* was funded for research in the area of Producing Positive Change in Health and Health Equity. You can learn more about SCR, their mission, and the Small Grant Program here.

Also, there would be no way in heck that this project could've happened without the help of my advisory committee. I have so much gratitude for their patience, wisdom, and time to guide me on this journey. Through the kindness of their being, they have given more than just knowledge; they've given the trust, confidence and belief that has been needed to foster this project into the form you see it in now. Thank you so much.

[1] University of Oregon, School of Journalism & Communication. (n.d.). About. Center for Science Communication Research. Retrieved April 3, 2026, from https://scr.uoregon.edu/

MICHAEL-BIOME

Much of the art in this presentation was a collaboration with my "Michael-biome," my family, friends, peers, and mentors. Much gratitude to the many wonderful people contributed to this project and my life.



HEY FRIENDS & FAMILY,
I NEED YOUR HELP!

After three years, I'm almost done with my master's in landscape architecture degree, and I'm putting my finishing touches on my terminal project.
I'm looking for some help with visualizing what we can't see: *MICROBES!*

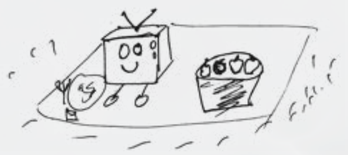
If you can, please draw, paint, or in any medium of your choice represent any of the items from the list here:

- *Bacteria*
- *Fungi*
- *Virus*
- *Archaea*
- *Mycelium*
- *Mushroom*
- *Extremophile*
- *Health*
- *Disease*
- *Accessibilty*
- *Biodiversity*
- *Soil*
- *Family Tree*
- *Invader*
- *Scientists*
- *The Public*
- *Students*
- *Louis Pasteur*
- *Emotions*
- *Communication*
- *Complexity*
- *Curiosity*
- *Data*
- *Survey*
- *Lab*
- *Weather Station*
- *Interactive Baby Toy*
- *Sound*
- *Microchip*
- *Audio Cable*
- *Music*
- *Speaker*
- *Computer Code*
- *Park*
- *Plants*
- *Trail*
- *River*
- *Farm*
- *Train*
- *Gravel Mine*
- *Fortress*

For extra fun, try combining multiple items, as shown in the connected boxes

Please create these in one color & send them to me before May 29th.
Make sure to add your name, initials or signature.
Even one sketch would be greatly appreciated.

Janet Walker



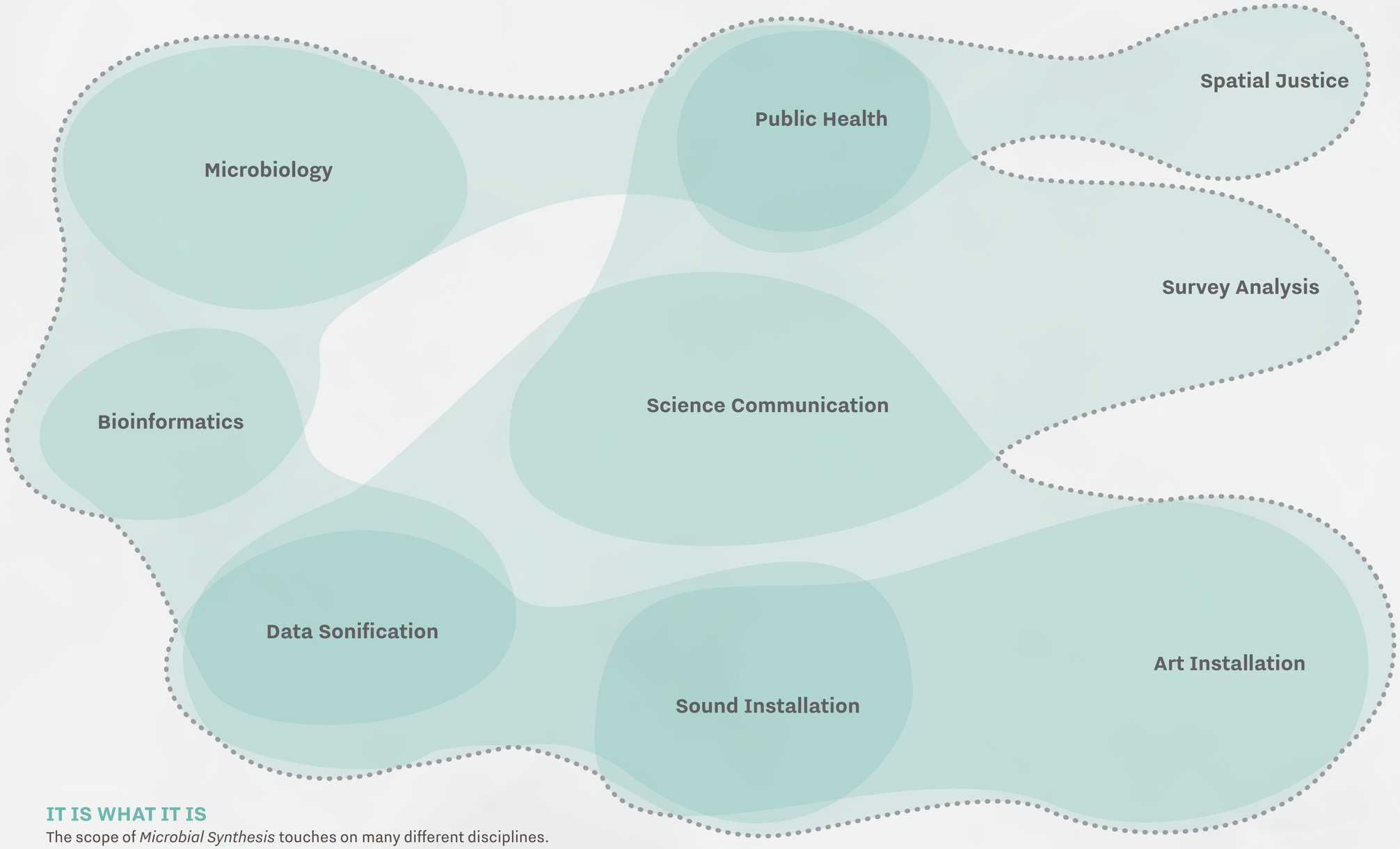
Allen Hancock

I may appear as a distinct unit: the single author of the document you're about to read. I am the result of the myriad connections of everyone in my life: my friends, family, mentors, peers, all the members of my cohort. To represent this, *Microbial Synthesis* had an extra element-- a creative campaign of collaboration with my "Michael-biome"

A flyer was created and shared with those important people in my life, requesting help with visualizing many of the elements and concepts relevant to my project. The resulting creative exploits can be seen throughout this booklet, with the name of the creator credited to the individual pieces. Anything uncredited drawing or graphic was created by myself.

This collective visual representation through the "Michael-biome" was inspired by the microbiological concept of holobiont, or the idea that no organism is an individual. Rather, a single tree, butterfly, or human is actually a mega-organism that consists of the individual host and its various microbiomes to form a symbiotic assemblage.[1] The sum is more than its parts.

[1] Margulis, L., & Fester, R. (Eds.). (1991). Symbiosis as a Source of Evolutionary Innovation: Speciation and Morphogenesis. MIT Press.



IT IS WHAT IT IS

The scope of *Microbial Synthesis* touches on many different disciplines.

My awareness of microorganisms and their beneficial effects grew exponentially when I helped establish Hardcore Compost, a bike-powered organic waste pick-up cooperative at the end of my undergraduate degree. We collected over one ton of food scraps a week, and I witnessed how the stacked piles of coffee grounds, watermelon rinds, and withered bouquets shrank and transformed into the “black gold” known as compost. This was a time of rich collaboration, both with my six other worker-owners and the myriad of microorganisms in our piles, as I found meaning through the magical cooperative act known as decomposition.

Seven years later, my microbial awareness has continued to expand and my Masters of Landscape Architecture final project, *Microbial Synthesis*, is its current culmination. Like a microbiome, this project is a complex assemblage— a collection of the many skills I’ve developed across the disciplines I’ve crossed during my academic career. The result is a design communication project that translates soil microbial data into a sound art installation with the goal of increasing microbial awareness, as microbes provide essential ecological and immune boosting functions but are often misunderstood and primarily associated with disease.

[1]Bryant, C. (2003). Does Australia need a more effective policy of science communication? International Journal for Parasitology, 33(4), 357–361. https://doi.org/10.1016/S0020-7519(03)00004-3

AWARENESS

The goal of this project is to develop awareness of microbes and their role in human health.

Awareness starts at a single point

Through cultivation similar phenomenon can be noticed

This can lead to noticing larger connections, informing actions

What this booklet details is a design communication project that translates soil microbial data into a sound art installation with the goal of increasing awareness, or the conscious or unconscious state of mind that can elicit action.[1,2,3] Awareness is the first step to change, which is critical when attempting a paradigm shift towards a better world. As the vehicle of transmitting awareness is an interactive sound installation, the intention is to create an enjoyable experience, or one that leaves participants with a pleasurable affect. [4]

As agents of change in the environment, Landscape architects must consider many goals, and I believe one is often missing: designing with microbes in mind.

I want to preface that I am not a microbiologist, and my goal here is to raise microbial awareness – primarily their role as one of the inextricable links between human health and ecological health. I believe that by expanding our awareness to the unseen, we can contemplate the invisible impacts of our actions. To begin, let's meet one of these types of microorganisms.

[1]Falkenberg, T. (2014). Awareness, Attention, and Noticing in Teaching and Teacher Education. In J. Mooney (Ed.), Contemplative Practice to Compassionate Learning Community: Developing and Sustaining the Teacher's Inner Life as a Site for Faculty Development.

[2]Gattegno, C. (1985). The Science of Education: Theoretical considerations. Educational Solutions.

[3]Mason, J. (2011). Noticing: Roots and Branches. In Mathematics Teacher Noticing. Routledge.

[4]Davies, S. R. (2015). Participation as Pleasure: Citizenship and science communication. In Remaking Participation. Routledge.

INTRODUCTION

Microbial Group:

FUNGI

Domain:

Eukarya

Size:

2.0 µm to 150 cm[1]

Three main functional groups:

1. Saprotrophic - degrades organic matter
2. Parasitic - benefits at the expense of its host, often causing disease
3. Mychorrhizal - forms a mutualistic relationship with some plants[2]

More closely related to humans than to bacteria, archaea, viruses and even plants[3]

More common in ecosystems dominated by perennial plants[4]

Spotlight Microbe:

GIGASPORA MARGARITA

Forms arbuscular (in root) mychorrhizal symbioses with soy beans, tomatoes and other crops[2]

Considered a metaorganism as it is a host to certain bacteria species that helps with its growth[5]

Genus Gigaspora found on every continent in the world except Antarctica[6]

Gigaspora margarita

https://tedhidanapamuji.blogspot.com/2017/08/koleksi-foto-mikoriza-dari-dr-arief.html

Fungi might be the most charismatic of all microorganisms. They are a close relative to us, as they are in the Eukarya domain, or the multicellular group of life, and humans are even more closely related to them than we are to plants. Mushrooms, the fruiting body of some fungi species, are found not just in the forest, but in all different forms of popular culture: fairy tales, video games, and the dinner table. There is now decades of research on the therapeutic effects on psilocybin, a compound found in some mushrooms, which has been found to reduce rates of depression and other psychiatric disorders.[7,8] The symbiotic relationship that arbuscular mycorrhiza has with some plant species in exchanging nutrients and helping them communicate to each other through the "wood wide web" has become a common talking point at the Saturday Market drum circle here in Eugene, Oregon. Central to fungi are hyphae, or the invisible thread-like branching structure of fungi that allow them to move through space, transporting itself and nutrients along the way.[9] As fungi develop, the invisible hyphae become a dense and complicated visible network known as mycelium, which manifests as the vegetative spore-spreading form of fungi, often as a mushroom. Mushrooms are temporary. They are a collective gift from the rain, the decaying matter, the plants that nourish the invisible network of mycelium that is connected to them all. When the temperature, moisture, and nutrients are aligned, these connections are made visible and can elicit an array of feelings: the delight when spotting a ruby red amanita, the craving when plucking a plump porcini, or even hope when being surrounded by morels in a forest post-burn. For a moment, the invisible underground world is made manifest. Magic is real.

[1] Barnes-Svarney, P., & Svarney, P. E. (2014). The Handy Biology Answer Book. Visible Ink Press. https://www.papertrell.com/apps/preview/The-Handy-Biology-Answer-Book/Handy%20Answer%20book/What-is-the-size-of-most-fungi/001137031/content/SC/52caffed82fad14abfa5c2e0_default.html

[2] Orgiazzi, A., Bardgett, R., Barrios, E., Behan-Pelletier, V., Briones, M., Chotte, J.-L., Deyn, G. B., Eggleton, P., Fierer, N., Fraser, T. D., Hedlund, K., Jeffery, S., Johnson, N., Jones, A., Kandeler, E., Kaneko, N., Lavelle, P., Lemanceau, P., Miko, L., & Wall, D. (2016). Global Soil Biodiversity Atlas. https://doi.org/10.2788/799182

[3] Georgia Tech Biological Sciences. (n.d.). Fungi. Organismal Biology. Retrieved May 4, 2026, from https://organismalbio.biosci.gatech.edu/biodiversity/fungi-2/

[4] Lowenfels, J. (with Lewis, W.). (2006). Teaming with microbes: A gardener's guide to the soil food web. Timber Press.

[5] Bonfante, P. (2022). Microbe Profile: Gigaspora margarita, a multifaceted arbuscular mychorrhizal fungus. Microbiology, 168(6), 001202. https://doi.org/10.1099/mic.0.001202

[6] Stürmer, S. L., Bever, J. D., & Morton, J. B. (2018). Biogeography of arbuscular mychorrhizal fungi (Glomeromycota): A phylogenetic perspective on species distribution patterns. Mycorrhiza, 28(7), 587–603. https://doi.org/10.1007/s00572-018-0864-6

[7] Lowe, H., Toyang, N., Steele, B., Valentine, H., Grant, J., Ali, A., Ngwa, W., & Gordon, L. (2021). The Therapeutic Potential of Psilocybin. Molecules, 26(10), 2948. https://doi.org/10.3390/molecules26102948

[8] Raison, C. L., Sanacora, G., Woolley, J., Heinzerling, K., Dunlop, B. W., Brown, R. T., Kakar, R., Hassman, M., Trivedi, R. P., Robison, R., Gukasyan, N., Nayak, S. M., Hu, X., O'Donnell, K. C., Kelmendi, B., Sloshower, J., Penn, A. D., Bradley, E., Kelly, D. F., … Griffiths, R. R. (2023). Single-Dose Psilocybin Treatment for Major Depressive Disorder: A Randomized Clinical Trial. JAMA, 330(9), 843–853. https://doi.org/10.1001/jama.2023.14530

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URBAN GREENSPACE

PHYSICAL HEALTH BENEFITS

MENTAL HEALTH BENEFITS

URBAN GREENSPACE HEALTH BENEFITS

Urban greenspace is a salutogenic landscape, one that offers health benefits such as exercise and mental relaxation in the increasingly impermeable environment we exist in.

Mushrooms may be associated with the forest, but all sorts of fungi can be found in our cities, often in our greenspaces, which can be key sites for bettering public health. Urban greenspace offer salutogenic, or health-promoting benefits both physically and mentally.[1] Different types of urban greenspace offer different health benefits, such as that public parks allow urban residents to exercise and recreate, with the added benefits of lowering stress and the risk of some diseases like obesity.[2] Urban agriculture not only provides the space to grow food for nourishment, but also the ability to grow a relationship with the land through cultivation.[1] Natural areas demonstrated that individuals experienced more positive emotions and therapeutic effects after spending time in them.[3,4]

Envisioning greenspace as a public health benefit isn't new for the discipline of landscape architecture, as in many ways it began as a public health movement. The intentions of Frederick Law Olmsted and Calvert Vaux's design for New York City's Central Park was not only for it to be an escape from the bustling city, but to provide fresh air.[5] Similarly, another landmark project by Olmsted, Boston's Emerald Necklace, was designed with the intent of promoting public health by promoting physical activity and providing a respite from crowded city.[6,7] While the world has changed quite a bit, contemporary urban green spaces can still be bastions for public health and in ways that we are just realizing.

[1] Thompson, C. W. (2015). Is landscape life? In Is Landscape… ? Routledge.

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[5] Jones, K. R. (2022). Green Lungs and Green Liberty: The Modern City Park and Public Health in an Urban Metabolic Landscape. Social History of Medicine, 35(4), 1200–1222. https://doi.org/10.1093/shm/hkac055

[6] O'Connell, J. C. (2016). The Legacy of Frederick Law Olmsted's Emerald Necklace in Contemporary Boston. Fábos Conference on Landscape and Greenway Planning, 5(1). https://doi.org/10.7275/fabos.641

[7] The Emerald Necklace: Boston's Green Connection (U.S. National Park Service). (n.d.). Retrieved June 10, 2026, from https://www.nps.gov/articles/the-emerald-necklace-boston-s-green-connection.htm

BIODIVERSITY HYPOTHESIS

Healthy urban greenspace can be a good source of beneficial microorganisms

less contact with diverse greenspace

less exposure to environmental microorganisms

higher rates of inflammatory and autoimmune diseases

Urban greenspaces can be a source for a diverse array of environmental microorganisms, which can help cultivate a healthy immune system. This is based on the biodiversity hypothesis, which suggests that declining contact with environmental microorganisms from urbanization has contributed to the rising rates of inflammatory and autoimmune diseases.[1]

Expanding our conception of urban greenspace beyond recreation and recognizing its critical role in a healthy society can help shift priorities in the development of human habitats. It's another reason for promoting biodiversity as recent studies have found that green spaces with higher plant diversity have more diverse microbial communities,[2] as well as provide stronger psychological restoration when compared to less biodiverse greenspace.[3] However, access to quality greenspace is inequitable, as low-income and marginalized communities often have poor access to parks.[4] The lack of greenspace access is compounded with microbial exposure through the concept of dysbiotic drift, or the unequal distribution of beneficial microorganisms due to socioeconomic disparities.[5] These communities need better access to greenspace, and biodiverse greenspace especially to receive the microbial health benefits.

[1] von Hertzen, L., Hanski, I., & Haahtela, T. (2011). Natural immunity. EMBO Reports, 12(11), 1089–1093. https://doi.org/10.1038/embor.2011.195

[2] Eisenhauer, N., Beßler, H., Engels, C., Gleixner, G., Habekost, M., Milcu, A., Partsch, S., Sabais, A. C. W., Scherber, C., Steinbeiss, S., Weigelt, A., Weisser, W. W., & Scheu, S. (2010). Plant diversity effects on soil microorganisms support the singular hypothesis. Ecology, 91(2), 485–496. https://doi.org/10.1890/08-2338.1

[3] Wood, E., Harsant, A., Dallimer, M., Cronin de Chavez, A., McEachan, R. R. C., & Hassall, C. (2018). Not All Green Space Is Created Equal: Biodiversity Predicts Psychological Restorative Benefits From Urban Green Space. Frontiers in Psychology, 9. https://doi.org/10.3389/fpsyg.2018.02320

[4] Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough.' Landscape and Urban Planning, 125, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017

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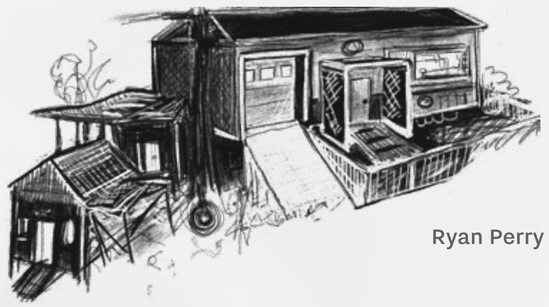
HUMAN EXISTENCE

evolved with for millions of years

adapted to quite recently

NATURAL ENVIRONMENT

BUILT ENVIRONMENT



Ryan Perry

increases exposure of

decreases exposure to

influences the health and well-being

OLD FRIENDS

We have evolved alongside microorganisms from the natural environments we used to inhabit. The materiality of the built environments favors different microbiomes than our “Old Friends”

“OLD FRIENDS”

Most of the microorganisms that offer health benefits are not random; many are “Old Friends” that humans have co-evolved with over millions of years and have major impacts on the overall well-being of their host.[1] These Old Friends are recruited from the air, plants, and the soil and can influence the composition of different human microbiomes, or the community of microorganisms that are specialized to a certain part of the human body.

For example, the bacteria *Streptomyces* are commonly found in the soil and naturally produce compounds known as metabolites that lower risks of allergies and autoimmune diseases, and these compounds can directly benefit human well-being when Streptomyces enters the human microbiome.[2] Streptomyces can be found in the gut microbiome, and has been found in lower quantities in the gut microbiomes of human populations living in urban areas when compared to humans who have a hunter-gatherer or agricultural based lifestyles.[3] The gut microbiome has a direct influence on physical health as its microorganisms have functional traits that aid in digestion. In addition, there is a growing body of research that shows that it has a close relationship to mental health, both influencing and being influenced by central nervous system disorders such as depression, alzheimers, and parkinsons among others.[4]

[1] Rook, G. (2023). The old friends hypothesis: Evolution, immunoregulation and essential microbial inputs. Frontiers in Allergy, 4. https://doi.org/10.3389/falgy.2023.1220481

[2] Bolourian, A., & Mojtahedi, Z. (2018). Streptomyces, shared microbiome member of soil and gut, as ‘old friends’ against colon cancer. FEMS Microbiology Ecology, 94(8), fiy120. https://doi.org/10.1093/femsec/fiy120

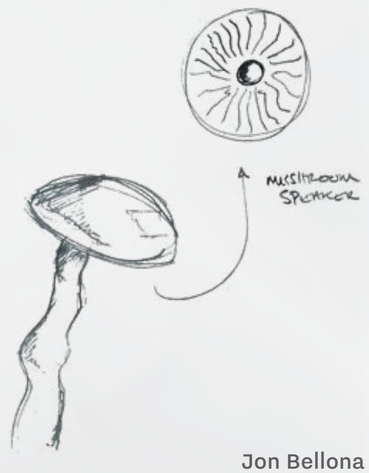
[3] Bolourian, A., & Mojtahedi, Z. (2018). Immunosuppressants produced by Streptomyces: Evolution, hygiene hypothesis, tumour rapalog resistance and probiotics. Environmental Microbiology Reports, 10(2), 123–126. https://doi.org/10.1111/1758-2229.12617

[4] Long-Smith, C., O'Riordan, K. J., Clarke, G., Stanton, C., Dinan, T. G., & Cryan, J. F. (2020). Microbiota-Gut-Brain Axis: New Therapeutic Opportunities. Annual Review of Pharmacology and Toxicology, 60(Volume 60, 2020), 477–502. https://doi.org/10.1146/annurev-pharmtox-010919-023628 Microbiology Reports, 10(2), 123–126. https://doi.org/10.1111/1758-2229.12617

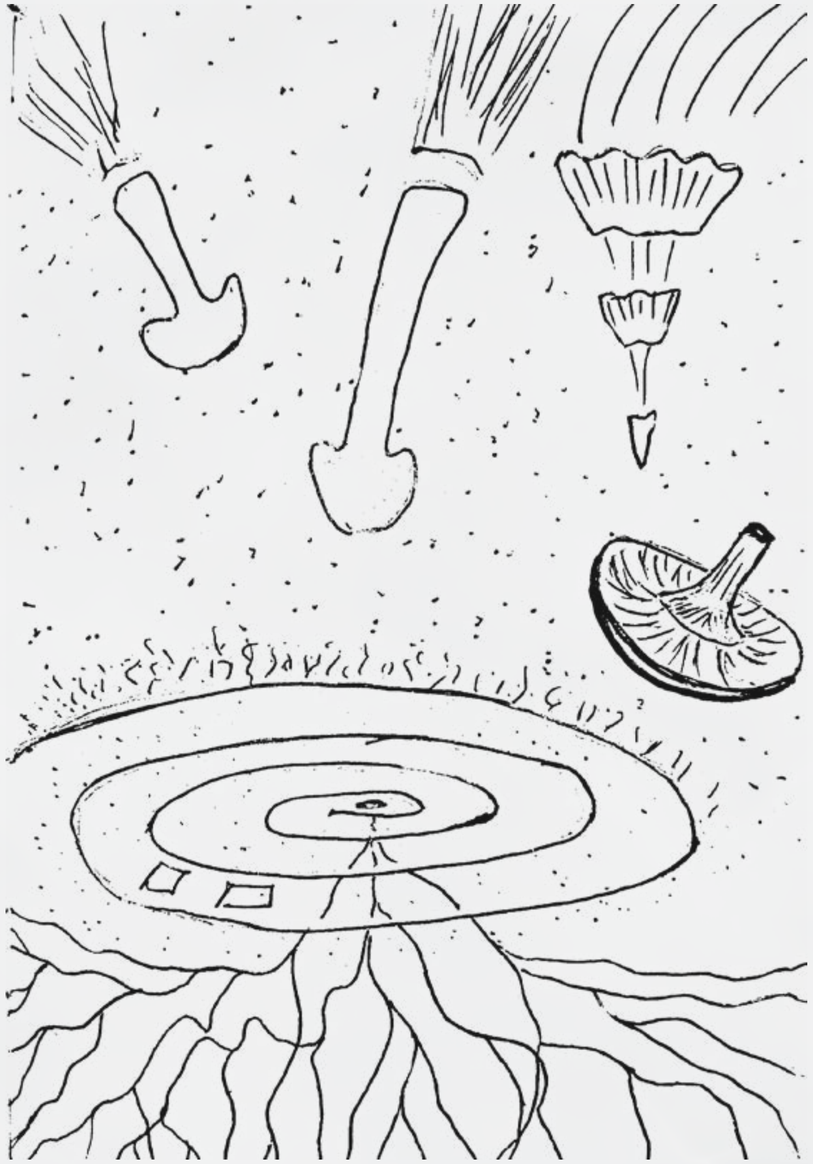
"We change through our collaborations both ***WITHIN AND ACROSS SPECIES.*** The important stuff for life on earth happens in those transformations, **not in the decision trees of self-contained individuals."**

Anna Tsing, PhD
The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins, 2015
Page 29

Derrick Mitchell



Jon Bellona



Paras Bajaj

THE ART OF NOTICING
Through her mulitspecies ethnography of matsutake mushroom foraging, Dr. Anna Tsing reveals how the art of noticing can unveil hidden dynamics between place, organisms, and the human systems.

As our "old friends" demonstrate, there is no such thing as an individual. We arise through myriads of interactions, macro and micro, conscious and subconscious. In Anna Tsing's book *Mushroom at the End of the World*, she reveals the sprawling world of the matsutake mushroom, and how it connects not only with pine and oak trees, but also to pericapitalist economies, refugee groups, and international peasant forestry practices.[1] Through focusing down to a single point, the matsutake, Tsing can pull on the knotted web of relations that the mushroom is entangled in.

As an environmental anthropologist, Tsing's work is rooted in multispecies ethnography, or an investigative method that questions the human-centric studies of the discipline to create a more inclusive and relation-based framework of conceptualizing the world.[2] Central to multispecies ethnography is Tsing's concept of the art of noticing, a mindfulness practice of observing the dynamic interconnectedness of all lifeforms.[3] Ask any mushroom forager and they will tell you this takes time to cultivate. As a novice, the difference between a choice edible mushroom and its toxic look-a-like is difficult, but with time the subtle differences become clear. The art of noticing becomes more difficult when the subject of investigation is unseen. Noticing starts at single point of awareness, allowing one to notice patterns through observation , which takes time to cultivate.

[1]Tsing, A. L. (2017). The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins. Princeton University Press. (Original work published 2015)

[2]Câmpeanu, C. (2023, February 21). A Short Introduction to Multispecies Studies and Ethnography. AnthroArt. https://theanthro.art/a-short-introduction-to-multispecies-studies-and-ethnography/

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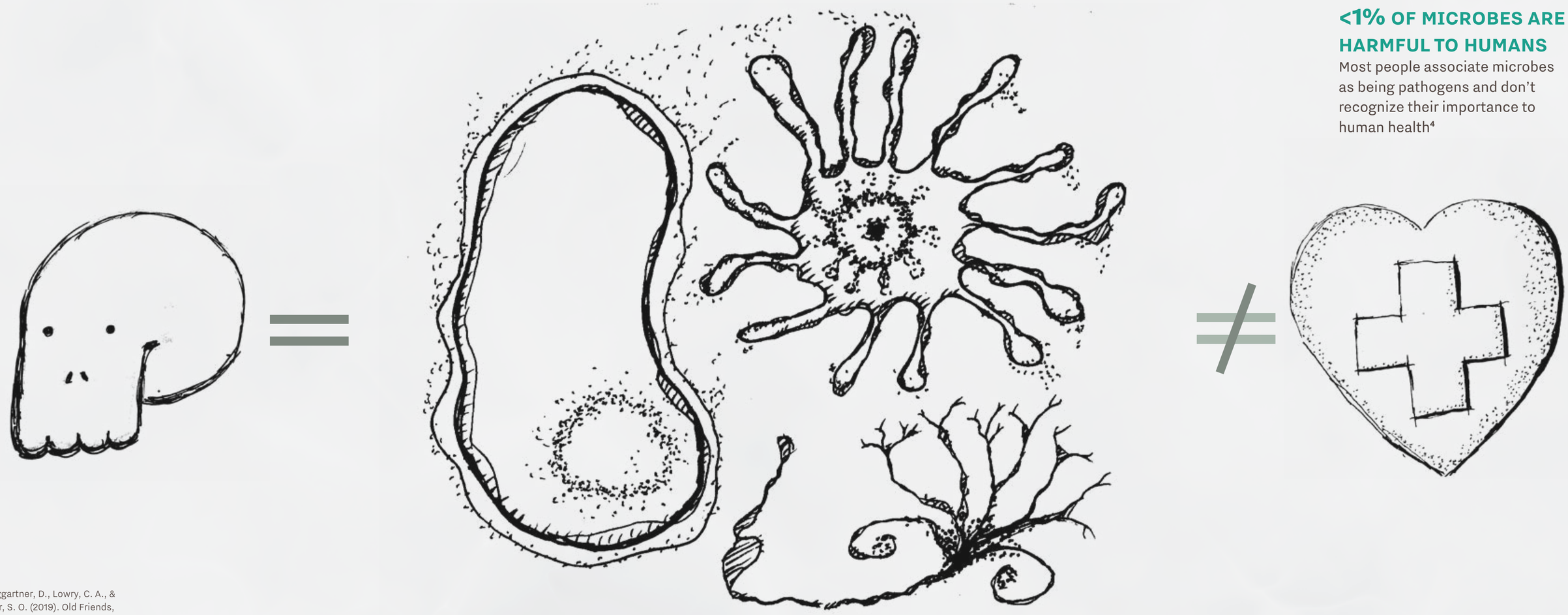

<1% OF MICROBES ARE HARMFUL TO HUMANS

Most people associate microbes as being pathogens and don't recognize their importance to human health[4]

Noticing can help humans understand that their health is connected to health of the environment, as the microbial "old friends" provide both immune-system support and reduce stress.[1] However, due to the fact that they operate at a scale invisible to human perception, general awareness of microorganisms remains minimal.[2,3] Public understanding of their role in human health in particular is limited, as microbes are still primarily associated with disease,[4] even though less than one percent are harmful to humans.[5] While this misconception may seem insignificant, this mischaracterization of microbes has encouraged a mindset of sanitization of our bodies, surfaces, and world.

[1] Langgartner, D., Lowry, C. A., & Reber, S. O. (2019). Old Friends, immunoregulation, and stress resilience. Pflügers Archiv - European Journal of Physiology, 471(2), 237–269. https://doi.org/10.1007/s00424-018-2228-7

[2] Chinthala, L. K. (2015). Microbes in Actio n: Ecological Patterns Across Environmental Gradients (SSRN Scholarly Paper No. 5232016). Social Science Research Network. https://doi.org/10.2139/ssrn.5232016

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[4] Carvalho, G. S., & Lima, N. (2022). Chapter 2 - Public perception of microorganisms and microbiology education: A need for enhancing society's microbiology literacy. In İ. Kurtböke (Ed.), Importance of Microbiology Teaching and Microbial Resource Management for Sustainable Futures (pp. 31–45). Academic Press. https://doi.org/10.1016/B978-0-12-818272-7.00006-7

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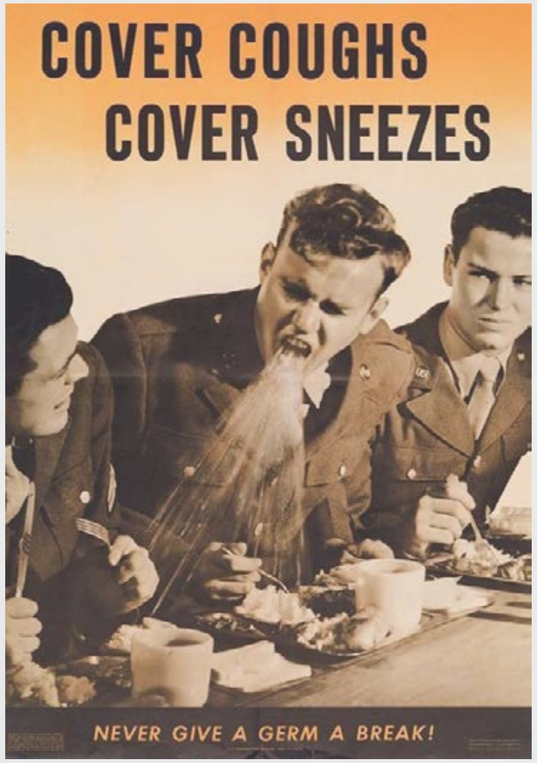
LOUIS LOUIS

Louis Pasteur is often referenced as the father of microbiology. He made breakthrough discoveries in understanding how microorganisms can cause disease like anthrax and popularized the sanitization “Pasteurization” of our food.

Dorissa Mitchell

Ayron Arellano



THE WAR ON “GERMS”

https://medicalmuseum.health.mil/micrograph/index.cfm/posts/2020/the_battle_against_germs

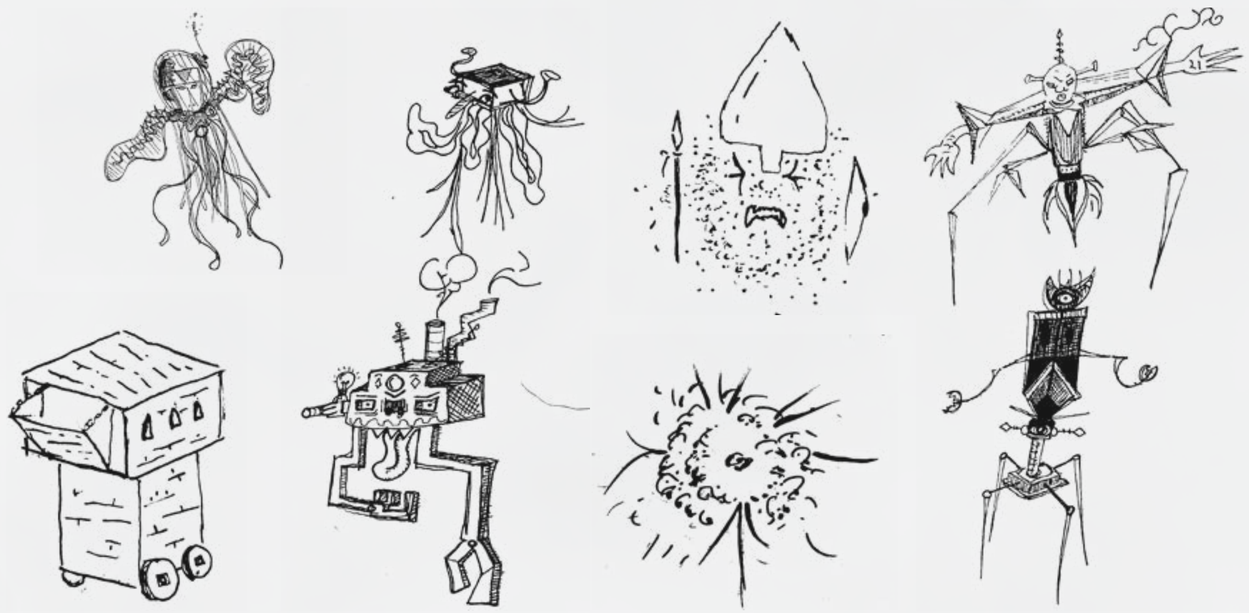
The collective consciousness of has inherited a fear of microorganisms for good reason. For most of human existence, we had no true idea of what made people sick. There was the miasma theory dating back to the ancient Greeks that postulated that “bad air” related to decaying matter was the cause of disease.[1] With the advent of the microscope in the 18th century, scientists learned that microorganisms exist. Thanks to experiments in the late 19th century by the chemist Louis Pasteur and others, scientists were able to prove that microorganisms cause food spoilage as well as disease.[2] This new Germ Theory of Disease had massive impacts, as it helped form the basis for the contemporary public health movement, and has made huge contributions to reducing the spread of disease.

However, this shift has put all microorganisms, whether beneficial or pathogenic, in the cross hairs of the “War on Germs.” By World War II, the connection between microbes and health became a war tactic, as militaries promoted hygiene to protect their troops. Conversely, militaries began investigating how microbes could be weaponized, as seen in the war crimes committed by Japan’s Unit 731 who tested microbiological weapons on Chinese civilians.[3] This perception of these invisible “threats” still linger, which can be seen in the conception of our immune system.

[1]Mertz, L. (2020). Miasma. Gale. The Gale Encyclopedia of Public Health. https://go.gale.com/ps/i.o?id=GALE%7CCX7947900186&v=2.1&it=r&sid=summon&u=euge94201&p=GRNR&aty=ip

[2]Newton, D. E. (2020). Germ Theory. Gale. The Gale Encyclopedia of Public Health. https://go.gale.com/ps/i.do?p=GRNR&u=euge94201&v=2.1&it=r&id=GALE%7CCX7947900124&retrievalId=86d55278-84c4-47dc-bb2e-fe364d2bbe98&inPS=true&linkSource=interlink&sid=bookmark-GRNR

[3]Kuhn, A. (2025, August 14). New details emerge about Japan’s notorious WWII germ warfare program. NPR. https://www.npr.org/2025/08/14/nx-s1-5497951/japan-germ-warfare-biological-wwii



PERSONAL SPACE INVADERS

The metaphor of the immune system as a fortress can create an antagonistic relationship with microbes

The “War on Germs” mindset can be heard in the language that surrounds our understandings and descriptions of health. The immune system is often depicted as a fortress, protecting individuals like a fortified citadel repelling invading germs.[1] The application of antibiotics in the 20th century created a new weapon in the fight,[2] but its overuse has enabled some pathogenic microorganisms to adapt and evolve into drug-resistant super-bugs.[3] These drug-resistant microbes are a threat to human health, but there needs to be some acknowledgment in how a sanitization mindset has helped create them. Anthropologist Heather Paxson argues that a mental shift needs to happen that no longer, “...treats the natural world as dangerously unruly and in need of human control...”, to a more inclusive perspective that, “...emphasizes the potential for cooperation among agencies of nature and culture, microbes and humans.”[4]

[1] Zach, M., & Greslehner, G. P. (2023). Understanding immunity: An alternative framework beyond defense and strength. Biology & Philosophy, 38(1), 7. https://doi.org/10.1007/s10539-023-09893-2

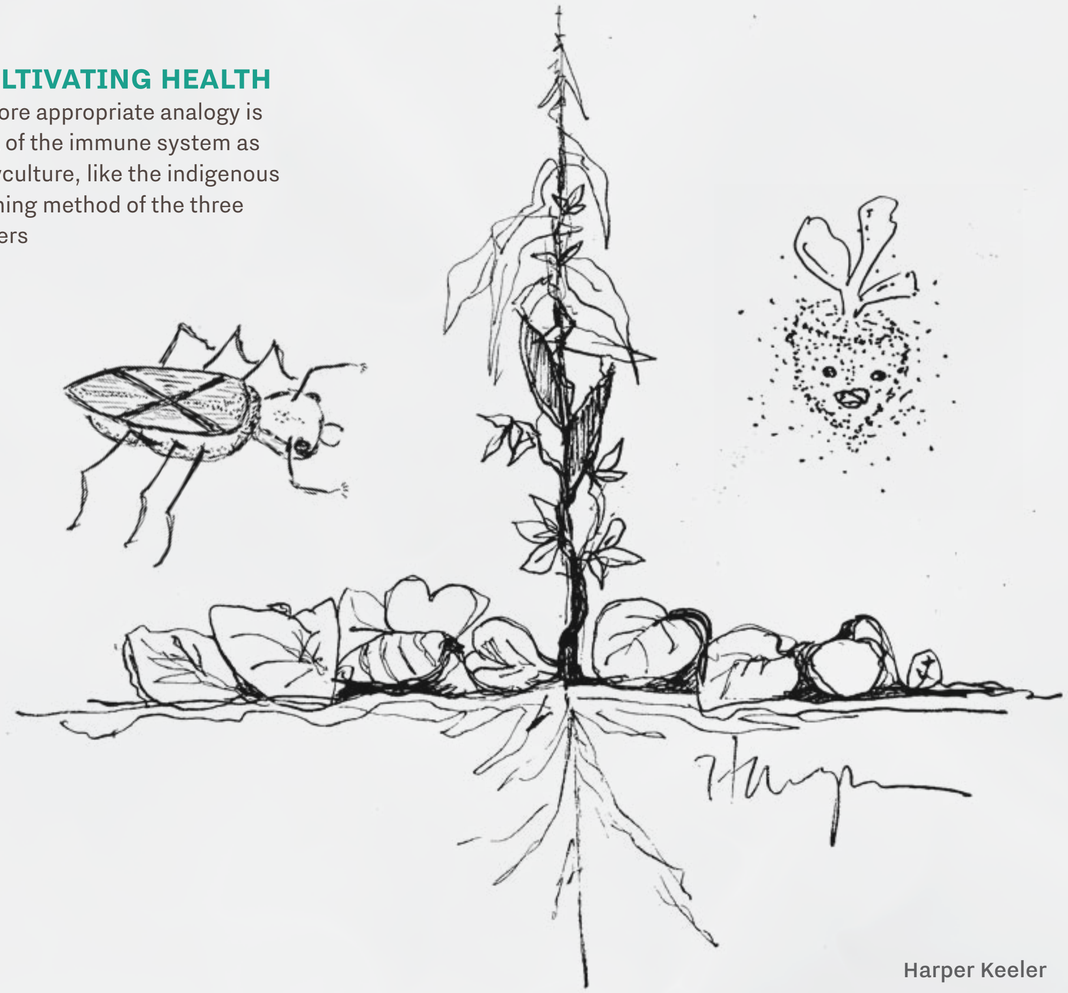
[2] Li, S., Liu, J., Zhang, X., Gu, Q., Wu, Y., Tao, X., Tian, T., Pan, G., & Chu, M. (2025). The Potential Impact of Antibiotic Exposure on the Microbiome and Human Health. Microorganisms, 13(3), 602. https://doi.org/10.3390/microorganisms13030602

[3] Saleem, M., Deters, B., Bastide, A. de la, & Korzen, M. (2019). Antibiotics Overuse and Bacterial Resistance. Annals of Microbiology and Research, 3(1), 93–99. https://doi.org/10.36959/958/573

[4] Paxson, H. (2013). The life of cheese: Crafting food and value in America (1st ed.). University of California Press. https://doi.

CULTIVATING HEALTH

A more appropriate analogy is that of the immune system as polyculture, like the indigenous farming method of the three sisters



Harper Keeler

VITAMIN D

Exposure to microorganisms are very important at a young age, because that is the most critical period for our immune system's development.

Emily Midyette

Cathy Holt

A better way of conceptualizing our immune system is that of a polyculture farm. Unknowingly, we are cultivating a field of microorganisms that play critical roles in our immune system.[1] Historically, it starts at birth when we inherit our mother's microbiome and continues to evolve through exposure to environmental microorganisms. This assemblage creates an adaptive immune system that acts like an integrated pest-management system, where a diverse microbiome contains natural predators towards pathogens.

Exposure to "old friends" can help with this cultivation, especially at a young age, as the 0 to 3 age range is the most critical period of our lives to recruit environmental microbes into ones immune system.[2] The soil is one of the places we can cultivate beneficial microorganisms, and we will dig into it a bit more in the next section.

[1] Rook, G., Bäckhed, F., Levin, B. R., McFall-Ngai, M. J., & McLean, A. R. (2017). Evolution, human-microbe interactions, and life history plasticity. The Lancet, 390(10093), 521–530. https://doi.org/10.1016/S0140-6736(17)30566-4

[2] Laue, H. E., Coker, M. O., & Madan, J. C. (2022). The Developing Microbiome From Birth to 3 Years: The Gut-Brain Axis and Neurodevelopmental Outcomes. Frontiers in Pediatrics, 10, 815885. https://doi.org/10.3389/fped.2022.815885

SOIL PILOT STUDY

Urban Farm Riverside & Willamette River Natural Area | 9.2024 - Ongoing

Microbial Group:

ARCHAEA

Domain:

Archaea

Size:

0.1 to 15 µm[1]

Considered to be an "Extremophile," as they can live in the widest temperature ranges of any organism from below 0 C to over 120 C[2]

Originally thought to be a type of bacteria,[2] actually more closely related to humans than bacteria[3]

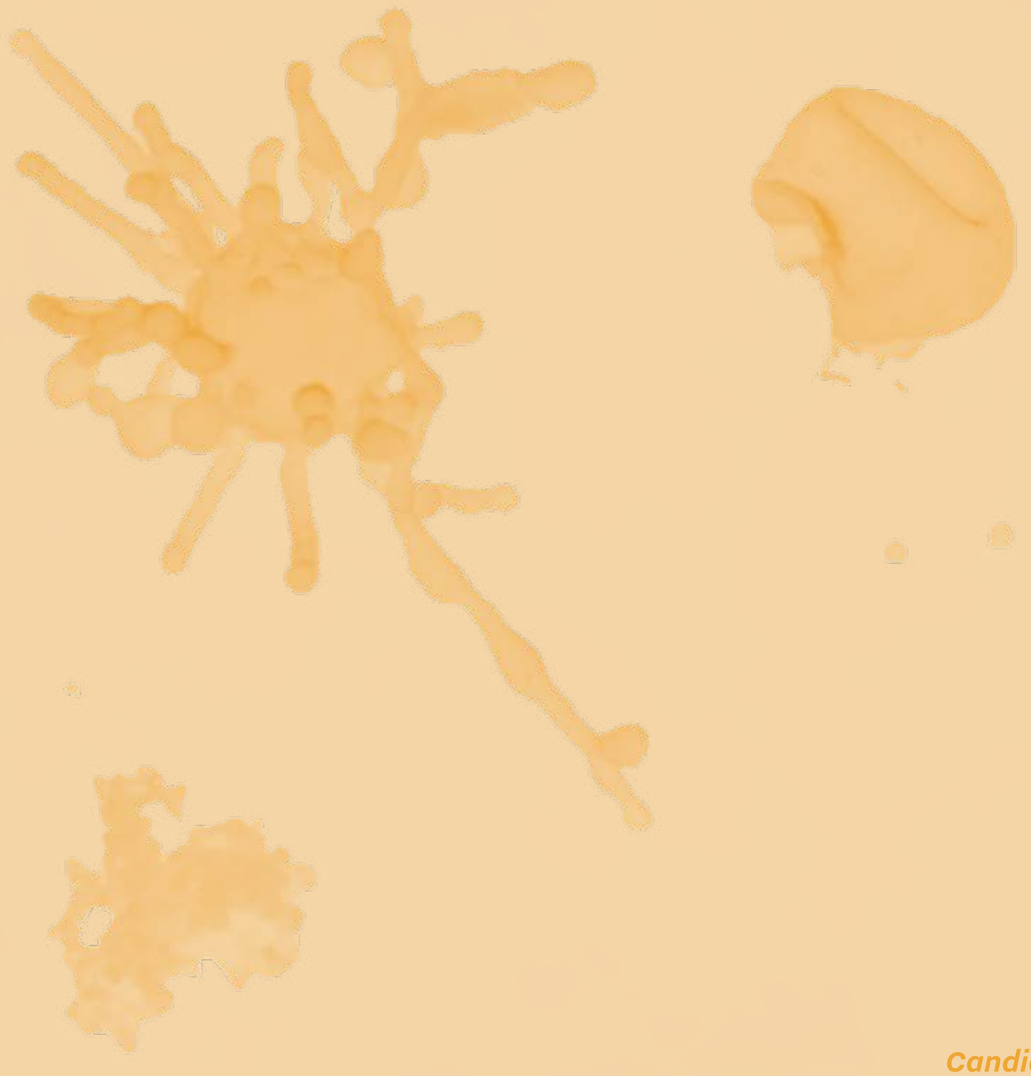
On average make up 10% of all microbial cells in soil, can be dominant species in extreme conditions[3]

Spotlight Microbe:

CANDIDATUS sp.

Uses ammonia as a source of energy[4]

Can fix carbon[4]



Candidatus sp.

https://www.sci.news/biology/asgard-archaea-

Archaea are an interesting bunch, and probably the least well known of the microorganism groups that are the focus of this booklet. They were originally thought to be a type of bacteria as they both lack a nucleus, but have since be put into a domain of their own after technological advancements in genomic sequencing in the 1990's revealed that they had a distinct evolutionary history from bacteria.

They can be found on ice caps, deep sea vents, and in your compost pile as they are best known as being an extremophiles, or an organism that can tolerate extreme temperatures. Most archaea can actually be found in more common places, as they make up 10% of all microbial cells in the soil.

[1]Dahal, P. (2023, October 8). Archaea: Habitat, Characteristics, Classification, Applications. https://microbenotes.com/archaea/

[2]Cavicchioli, R. (2011). Archaea—Timeline of the third domain. Nature Reviews Microbiology, 9(1), 51–61. https://doi.org/10.1038/nrmicro2482

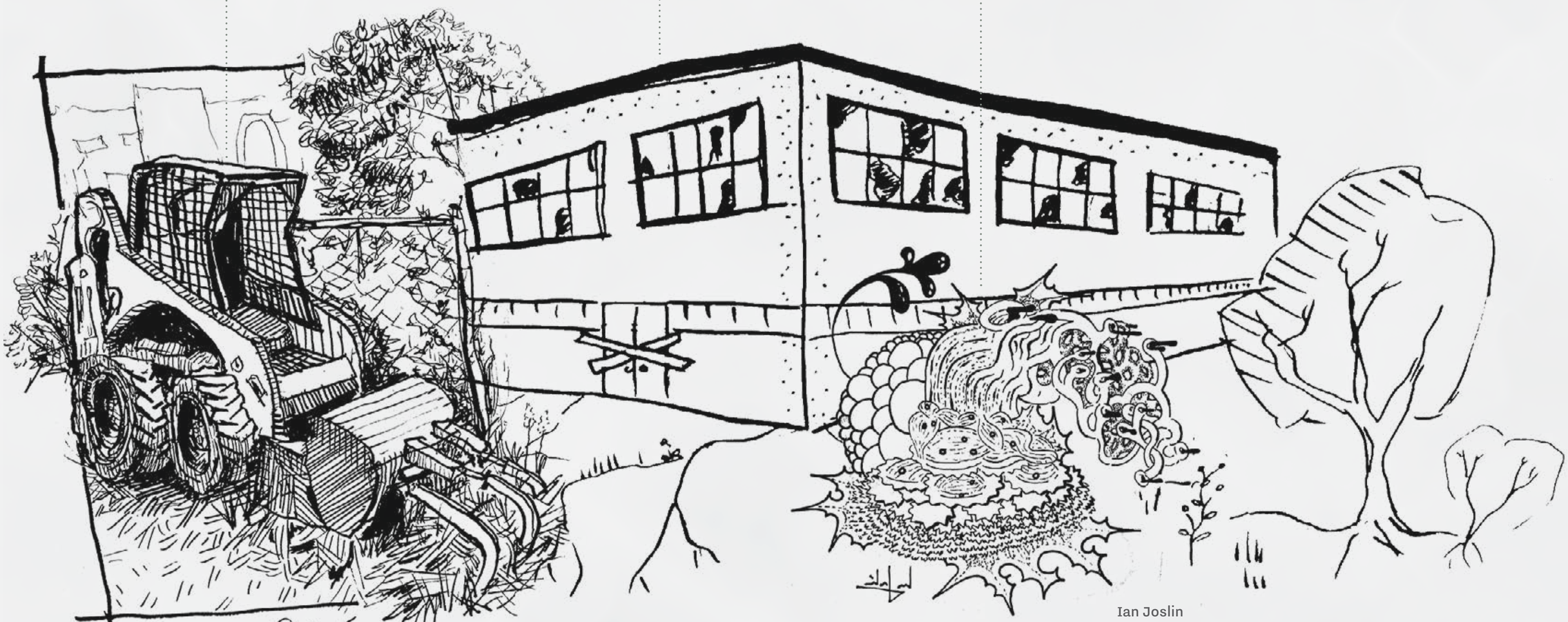
[3]Orgiazzi, A., Bardgett, R., Barrios, E., Behan-Pelletier, V., Briones, M., Chotte, J.-L., Deyn, G. B., Eggleton, P., Fierer, N., Fraser, T. D., Hedlund, K., Jeffery, S., Johnson, N., Jones, A., Kandeler, E., Kaneko, N., Lavelle, P., Lemanceau, P., Miko, L., & Wall, D. (2016). Global Soil Biodiversity Atlas. https://doi.org/10.2788/799182

[4]Sauder, L. A., Albertsen, M., Engel, K., Schwarz, J., Nielsen, P. H., Wagner, M., & Neufeld, J. D. (2017). Cultivation and characterization of Candidatus Nitrosocosmicus exaquare, an ammonia-oxidizing archaeon from a municipal wastewater treatment system. The ISME Journal, 11(5), 1142–1157. https://doi.org/10.1038/ismej.2016.192

Urban Soils
Highly varied due to constant disturbance

Urban Brownfields
Vacant lots of former industry

Pollution
The soil in urban brownfields can have high levels of pollution like heavy metals



Daniel Phillips

Ian Joslin

As industry has left most major cities in the US over the past seventy years, urban brownfields have become more abundant. These are former industrial or commercial sites which typically have varied soil quality as they can have high pollution levels.[1] Urban soils in general have high variation in their quality, structure and fertility because of continual disturbance, pollution exposure, and variation in land use.[2] Due to these impacts, urban soils also have highly varied microbial communities[3] that can be potentially dysbiotic and dangerous, as some studies shown these spaces to have higher populations of microbial pathogens.[4]

Urban brownfields are often some of the few undeveloped open spaces remaining in the urban core and provide an opportunity for transforming the built environment's most contaminated spaces into biodiverse hotspots that provide social and physical health benefits.[6]

[1] Preston, P. D., Dunk, R. M., Smith, G. R., & Cavan, G. (2023). Not all brownfields are equal: A typological assessment reveals hidden green space in the city. Landscape and Urban Planning, 229, 104590. https://doi.org/10.1016/j.landurbplan.2022.104590

[2] Igalavithana, A. D., Lee, S. S., Niazi, N. K., Lee, Y.-H., Kim, K. H., Park, J.-H., Moon, D. H., & Ok, Y. S. (2017). Assessment of Soil Health in Urban Agriculture: Soil Enzymes and Microbial Properties. Sustainability, 9(2), Article 2. https://doi.org/10.3390/su9020310

[3] Nugent, A., & Allison, S. D. (2022). A framework for soil microbial ecology in urban ecosystems. Ecosphere, 13(3), e3968. https://doi.org/10.1002/ecs2.3968

[4] Chien, S.-C., & Knoble, C. (2024). Uneven Burdens: The Intersection of Brownfields, Pollution, and Socioeconomic Disparities in New Jersey, USA. Sustainability, 16(23), 10535. https://doi.org/10.3390/su162310535

[5] Felson, A. J., & Pickett, S. T. (2005). Designed experiments: New approaches to studying urban ecosystems. Frontiers in Ecology and the Environment, 3(10), 549–556. https://doi.org/10.1890/1540-9295(2005)003%255B0549:DENATS%255D2.0.CO;2

URBAN FARM RIVERSIDE & WILLAMETTE RIVER NATURAL AREA

On University of Oregon's campus in Eugene Oregon, there is an urban brownfield that is currently undergoing a large change, the Urban Farm Riverside (UFR) and Willamette River Natural Area (WRNA). The UFR is an extension of the Urban Farm, which in 2023 lost about 40% of its land for the expansion of a new scientific facility, the Knight Campus.[1] Thanks to the outcry and protest of dedicated students,[2,3] the University of Oregon gave an allotment of almost 2 acres of land to the Urban Farm on the Willamette River along with a 1 million dollar budget to help with the establishment of a new urban agriculture research hub. While having a riverside farm may sound ideal, the fact is that you can't transplant a farm like you can transplant a veggie.

The original Urban Farm has been building up its soil and community for almost fifty years now,[1] both of which are critical to food production[4] and take time to establish. To help guide the development of the UFR, professors Ignacio Lopez-Buson and Mary Polites led the 2024 Fuller Summer Studio, where an interdisciplinary group of design students created an ASLA award winning master plan for the site to envision and guide the development of such a complex space. As one of these students, this studio helped me see this site's potential, and it raised questions about what is happening beneath the surface and how its past has influenced its current conditions.

[1] University of Oregon. (n.d.). About. The Urban Farm. from https://urbanfarm.uoregon.edu/about/

[2] Gamez, G. (2022, November 14). Save the Urban Farm marches against more Knight Campus development. Daily Emerald. https://dailyemerald.com/45228/news/save-the-urban-farm-marches-against-more-knight-campus-development-2/

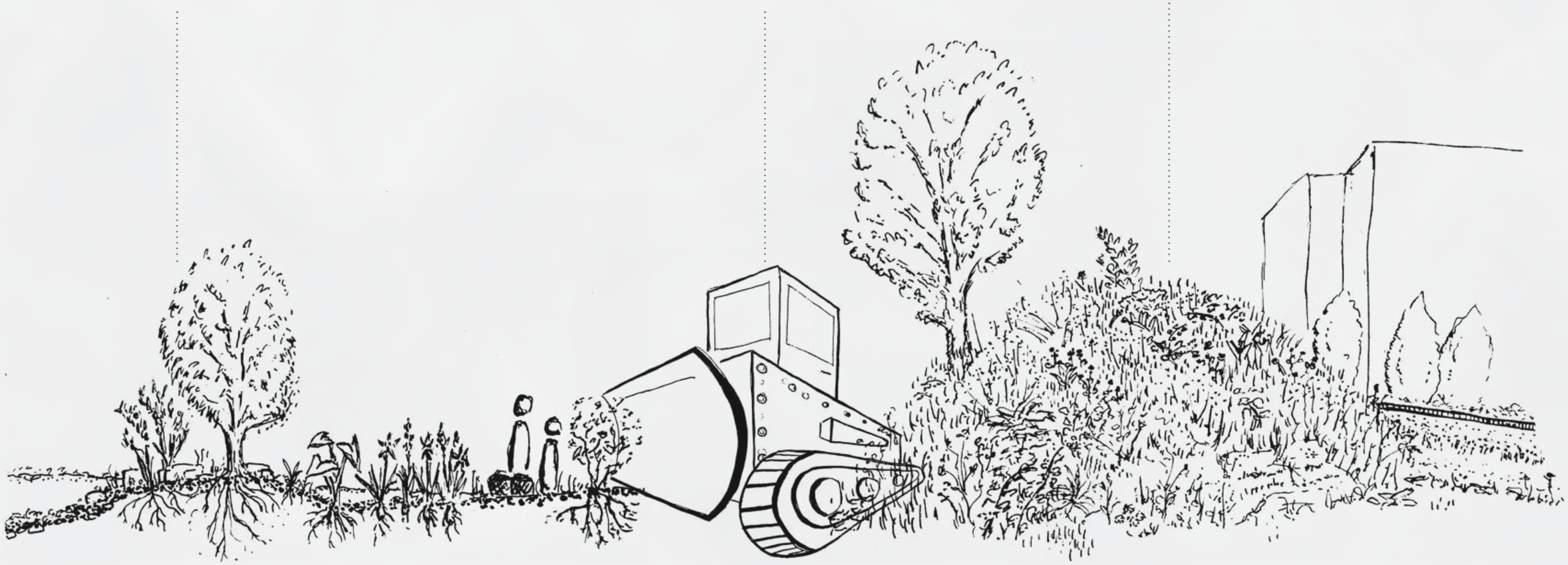
[3] McDonald, R. (2022, May 5). Urban Farm supporters fear encroachment from UO Knight Campus. KLCC | NPR for Oregonians. https://www.klcc.org/education/2022-05-05/urban-farm-supporters-fear-encroachment-from-uo-knight-campus

[4] Salomon, M. J., & Cavagnaro, T. R. (2022). Healthy soils: The backbone of productive, safe and sustainable urban agriculture. Journal of Cleaner Production, 130808. https://doi.org/10.1016/j.jclepro.2022.130808

The braiding pattern of the river created many side channels and pools through the riparian forest

The site's form was altered heavily by gravel mining, creating a steep bank with a flat terrace

Topsoil from Urban Farm transported to UFR. Currently waiting to be spread.



Time immemorial - 1900 CE
Riparian Forest

1900 - 1965 CE
Gravel Mine

2024 CE - Present
Urban Farm Riverside

WHAT WAS & WHAT IS LEFT

The history of what is now the UFR & WRNA shows how this space has changed from a wide riparian forest utilized and shaped by the Kalapuya, to a gravel mine, to it's current limbo state waiting to be restored and developed.

It's important to acknowledge that the UFR and the entirety of UO is on indigenous land. Pre-colonization, this space had been a riparian woodland that was stewarded since time immemorial by the Kalapuya people, until they were forcibly removed to Grand Ronde Reservation after a series of treaties were signed in the 1850's.[1] Almost nothing remains of what this space would've looked like to the Kalapuya, mainly because of the site's extractive history and how it resembles indigenous scholar Dr. Kyle Whyte's concept of vicious sedimentation, or "... the pattern of how environmental changes compound over time to reinforce and strengthen settler ignorance against Indigenous peoples." [2]

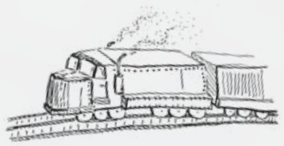
The Willamette River's form of a braiding river, shifting and seasonally flooding much of the valley floor, has been restrained due to channelization and damming. The site's current form of a steep riverbank and flat terrace is the result of its industrial past as a gravel mine in the early 20th century. [3] This operation scraped the riverbed for gravel and built up its current form by backfilling the mine using construction debris. The University purchased it in 1968, where it has sat vacant and compact waiting to be developed.

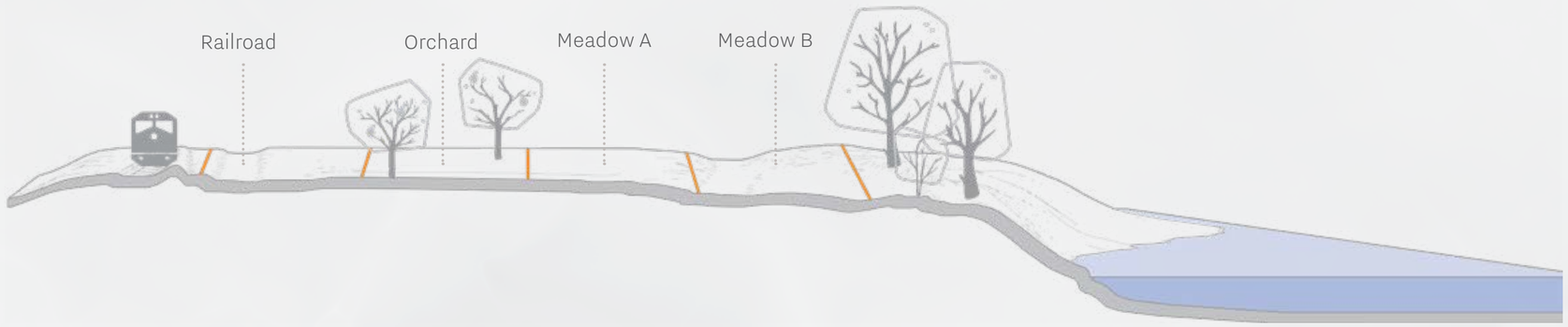
This land has experienced trauma. It has been stolen, exploited and degraded. However, the redevelopment of this space provides a moment to acknowledge this messy history and decide how this space can heal and grow.

[1] Lewis, D. G. (2023). Tribal Histories of the Willamette Valley. Ooligan Press.

[2] Whyte, K. (2018). Settler Colonialism, Ecology, and Environmental Injustice. Environment and Society, 9, 125–144.

[3] Krueger, J. (2022). Willamette River Natural Area Landscape Management Plan. University of Oregon. https://cpfm.uoregon.edu/sites/default/files/uo_wrna_landscape_management_plan_final_6_2022_1.pdf





SECTION A
The microbiological pilot study was performed on a transect from the railroad to the Willamette River.

A soil pilot study experiment was conducted to investigate the current soil conditions on site, with a focus on examining the soil microbiome composition. A set of research questions was developed to investigate the impacts of past human activity.

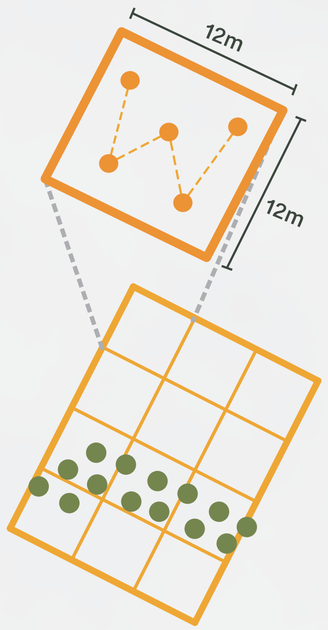
- What are the differences in soil quality across an urban brownfield?
- How do the microbial communities differ?
- What heavy metals are present on site, and at what concentrations?
- How does the proximity of the river and railroad tracks impact the soil?

Due to the large area of the UFR and WRNA, a smaller section of the site was selected to be the research area for feasibility and financial reasons. The research area was oriented as a transect from the existing railroad line on the southern end to the Willamette River on the north end of the site. The railroad and river could impact the soil conditions of the site by being potential sources for pollutants, chemicals, microbes and more. The location of the research area was selected to cross through a recently transplanted orchard from the original Urban Farm, generally followed the slight decrease in elevation from railroad to river, and encompassed site conditions that were representative of the larger UFR & WRNA. In total, the sampling site encompassed three parallel transects each containing four 12x12 m^2 sample plots, to provide replicates to perform statistical analysis.

① FIELD WORK

Location: **UFR & WRNA**
Date: **9.2024**

Collect Soil Samples



Five soil samples were collected and combined from each plot in the research area.

② LAB WORK

Location: **Institute for Health in the Built Environment Lab**

Process Soil

Soil samples were sieved to fine a homogeneous texture.

Extract DNA

The DNA in the processed soil was extracted from each sample.

3.a PHYSICAL & CHEMICAL TESTING

Location: **Oregon State University Soil Health Lab**

Basic Soil Health Assessment

Heavy Metal Analysis

Soil samples were sent to a lab at Oregon State University to have its physical and chemical properties tested, along with heavy metals.

3.b MICROBIOME SEQUENCING

Location: **University of Oregon Genomics & Cell Characterization Core Facility**

Shotgun Metagenomic Sequencing

Extracted DNA was sent to a facility on the University of Oregon's campus to be sequenced.

④ ANALYSIS

Location: **The Computer**

Process Data

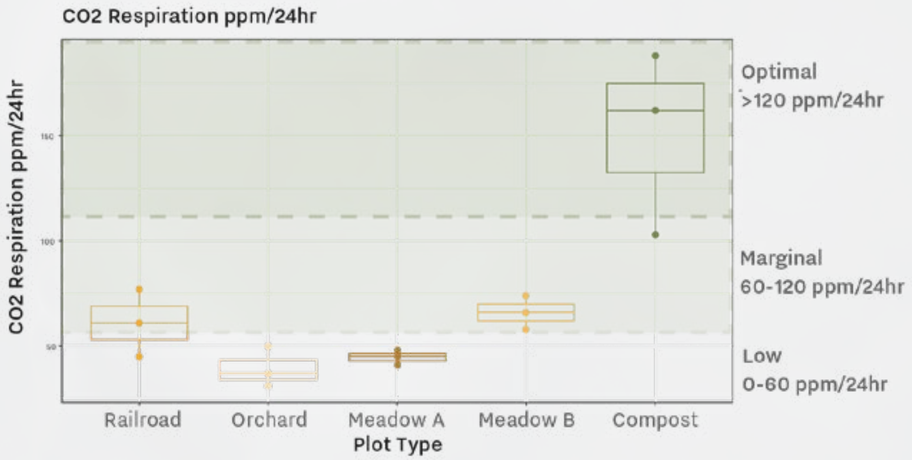
The resulting data from both the physical and chemical soil properties as well as the microbiome DNA was analyzed used the statistical program R.

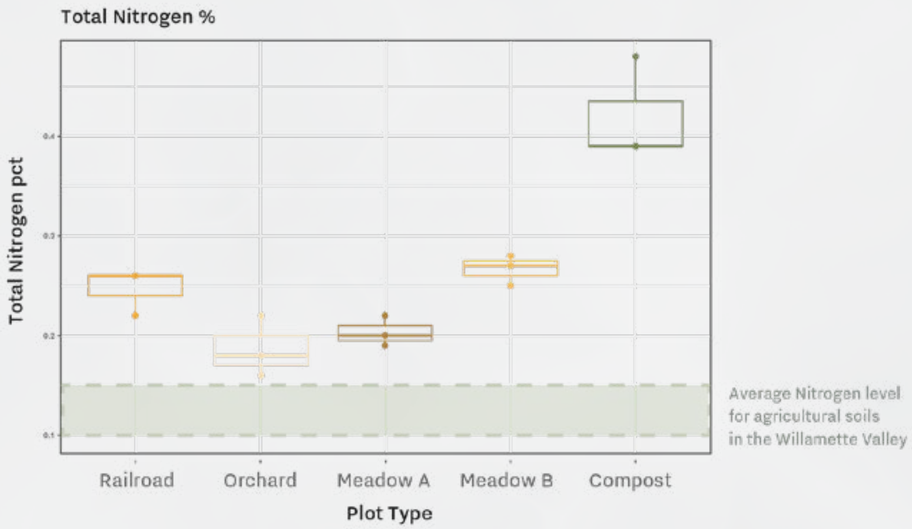
① Soil samples were collected from each plot in late September 2024, following guidelines outlined in the Cornell Comprehensive Assessment of Soil Health.[1] Five cores were extracted per plot using a "W" sampling pattern, with a minimum distance of 4.5 meters between core to obtain the top 10 cm of the soil profile. Tools were sanitized between each sample collection to reduce risk of cross-contamination.

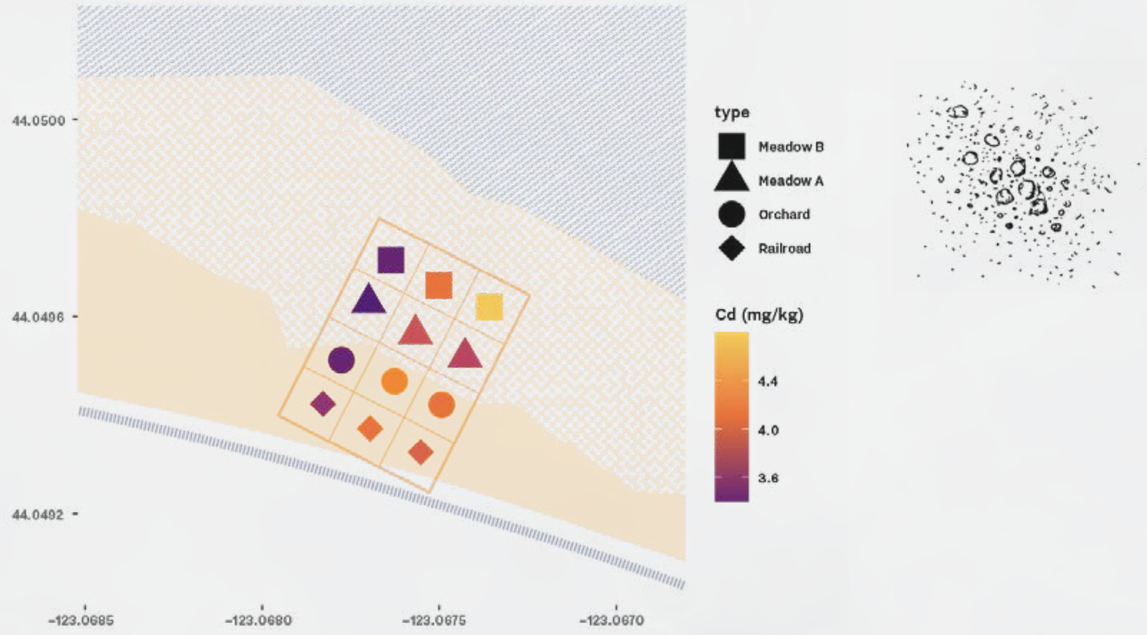
②Immediately after collection, all samples were stored in a freezer at -20° C to maintain sample integrity and prevent any chemical changes. To prepare them for lab work, samples were sieved to remove debris and have a fine texture. 3.a Two small samples (0.25g) were set aside for DNA extraction, and the remaining soil was sent to Oregon State University for a basic soil assessment for physical and chemical analysis, which included pH, organic matter, nutrients, and heavy metal content.

DNA was isolated from the samples using a DNeasy PowerSoil Pro Kit, following a multistep process of pipetting, filtering and centrifuging the sample. 3.b The extracted DNA was then sent to the University of Oregon Genomics & Cell Characterization Core Facility to be sequenced. qPCR was conducted for bacteria in the soil, but there was an issue at some point during the process. The results for most samples showed no amplification. ④ The results were then imported into the statistical analysis program R, to be cleaned processed and organized taxonomically.

[1]Comprehensive Assessment of Soil Health. (2017). Cornell University. https://cornell.app.box.com/s/ryy6xgtwok5l85zzy9fgms1276drud0y







SO HEAVY

Out of all the heavy metals tested, cadmium was the only one to appear in levels that were above expected.

The results of showed that the site was overall high in nitrogen, a key nutrient in plant development. However, plants rely on microbes to make nitrogen available to them, as only 1-4% of total nitrogen is actually available for plants.[1] A simple test for gauging the amount microbial activity in the soil, CO_2 respiration, showed that site had low microbial activity. The test works by measuring the CO_2 levels in the soil as microbes exhale just like other organisms. The low levels may indicate that plants may not be obtaining the high levels of nitrogen present in the soil.

Cadmium was the only heavy metal on site that was above expected levels. All samples exceeded the default background concentration of 1.6 ppm,[2] as the sample with the lowest concentration being 3.4 ppm. This metal occurred in higher concentrations along the eastern end of the site, slightly increasing towards the river. The levels found at the site are not dangerous according to Oregon DEQ, but is noteworthy as this site is meant to grow food.[2] Cadmium builds in the human body through breathing and digestion, stays in the human body for up to 30 years, and can cause organ failure through long term exposure.[3] Cadmium can also inhibit plants' ability to take up nutrients like iron, magnesium, calcium, and potassium.[4] So while the cadmium levels may not be dangerous immediately, the higher concentrations could be a point of concern over time for those working the land, and may inhibit plant development.

[1] Fenton, M., Albers, C., & Ketterings, Q. (2008). Soil Organic Matter Fact Sheet. Cornell University Cooperative Extension. https://franklin.cce.cornell.edu/resources/soil-organic-matter-fact-sheet#:~:text=Soil%20organic%20matter%20is%20the%20fraction%20of,to%20soil%20productivity%20in%20many%20different%20ways.

[2] Background Levels of Metals in Soils for Cleanup. (2018). State of Oregon Department of Environmental Quality. https://www.oregon.gov/deq/FilterDocs/cu-bkgrmetals.pdf

[3] Charkiewicz, A. E., Omeljaniuk, W. J., Nowak, K., Garley, M., & Nikliński, J. (2023). Cadmium Toxicity and Health Effects—A Brief Summary. Molecules, 28(18), 6620. https://doi.org/10.3390/molecules28186620

[4] Rahi, A. A., Younis, U., Ahmed, N., Ali, M. A., Fahad, S., Sultan, H., Zarei, T., Danish, S., Taban, S., El Enshasy, H. A., Tamunaidu, P., Alotaibi, J. M., Alharbi, S. A., & Datta, R. (2022). Toxicity of Cadmium and nickel in the context of applied activated carbon biochar for improvement in soil fertility. Saudi Journal of Biological Sciences, 29(2), 743–750. https://doi.org/10.1016/j.sjbs.2021.09.035

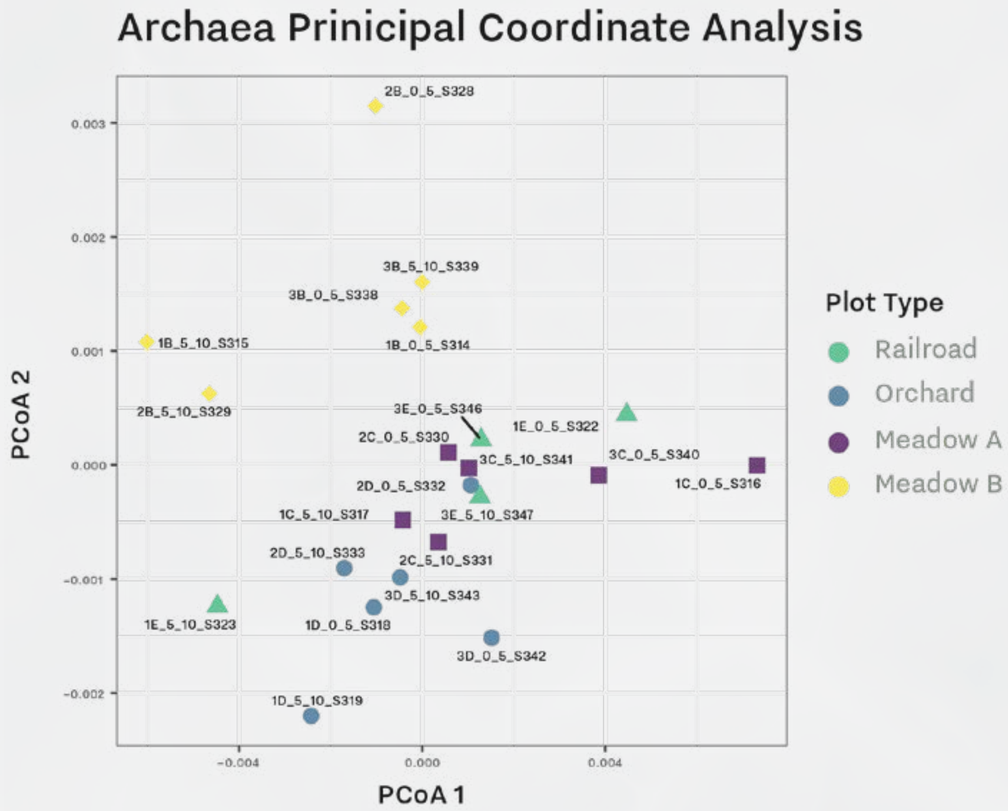


figure 1

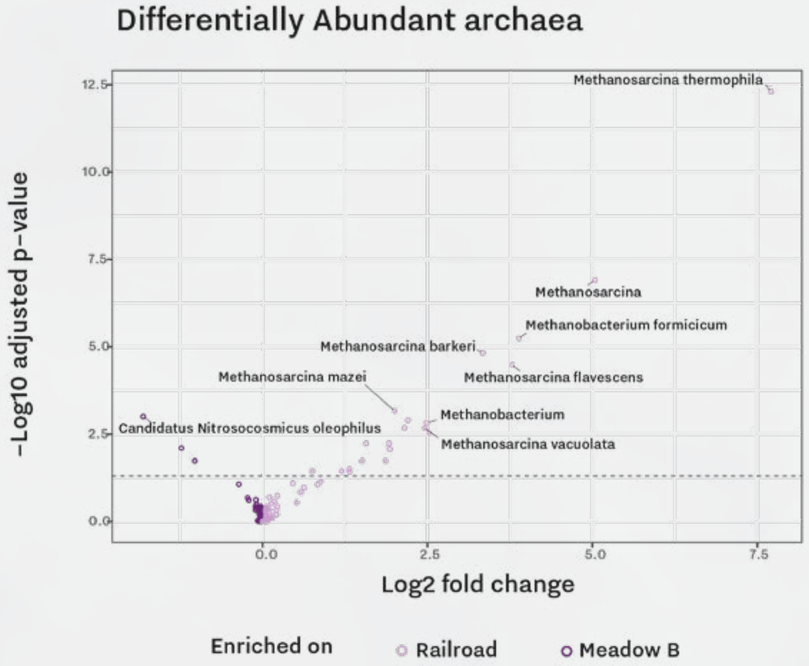


figure 2

THIS IS WHAT MICROBIAL DIVERSITY LOOK LIKE

Principal Coordinate Analysis allows for the betadviersity, or comparative diversity of different microbial populations to be compared. Similarly, volcano plots allow for a per-species comparison between two specific samples.

Beta diversity analysis was conducted using the Morisita-Horn dissimilarity index to examine the degree of differentiation among the different sections of the site to see if there were any difference between their microbial compositions. Overall, there wasn't any statistically significant difference in the difference between the microbiomes overall (figure 1), but there was differences in specific species.

In terms of species enrichment, results varied for different microbial kingdoms, as bacteria had high variations of enrichment of different taxa across the most of the land use types, archaea had some differentiation, while fungi and virus had no statistically significant differences in enrichment.

Overall, the Railroad type had a highest amount of bacterial species enriched compared to the Orchard, Meadow A and Meadow B. The Railroad had over double the amount of enriched species (108) when compared to the Meadow B (48), and this disparity was even greater for Railroad (118) and Meadow A (32).

Archaea had a similar trend in enrichment differentiation as bacteria with the Railroad type having the highest amount when compared to the other types, except for Orchard where they both only had one archaea taxa that was enriched. Railroad (21) had seven times the number of archaea taxa when compared to Meadow B (3) (figure 2). Like the bacteria beta diversity, Railroad (25) had the highest difference between Meadow A (0) for archaea taxa enrichment.

Graphs like the PCoA analysis and volcano plot on the previous page, are a form of data visualization, which is one of the most common ways to display the results from an scientific experiment. Data visualization has a lot of benefits, however in the field of microbiology, an audience typically needs to have some sort of background in this subject to really understand what is being communicated.

As a budding researcher, I want my research to not only be rigorous, but also meaningful, which can be hard to do when your lens becomes so narrow it's actually microscopic. As my degree is in landscape architecture and not microbiology, I wanted to use this research to be the foundation for my final MLA project, allowing me to build on it by employing some of the many design skills I've developed in my program. The result is Microbial Synthesis, a design communication project that turns away from the typical research path of data visualization, by using the novel science communication method of data sonification.

MICROBIAL SYNTHESIS

Microbial Group:

BACTERIA

Domain:

Bacteria

Size:

0.2 to 2.0 µm[1]

Most common life form on the planet[2]

Likely the origins of life on planet Earth[2]

First photosynthesizers with fossils of oxygen producing bacteria being over 3.5 billion years old[2]

Three main different shapes: Round (Cocci), Rod (Bacilli), & Spiral (Spirilla & Spirochetes)[3]

Play important role in nutrient cycling in soil health[4]

Spotlight Microbe:

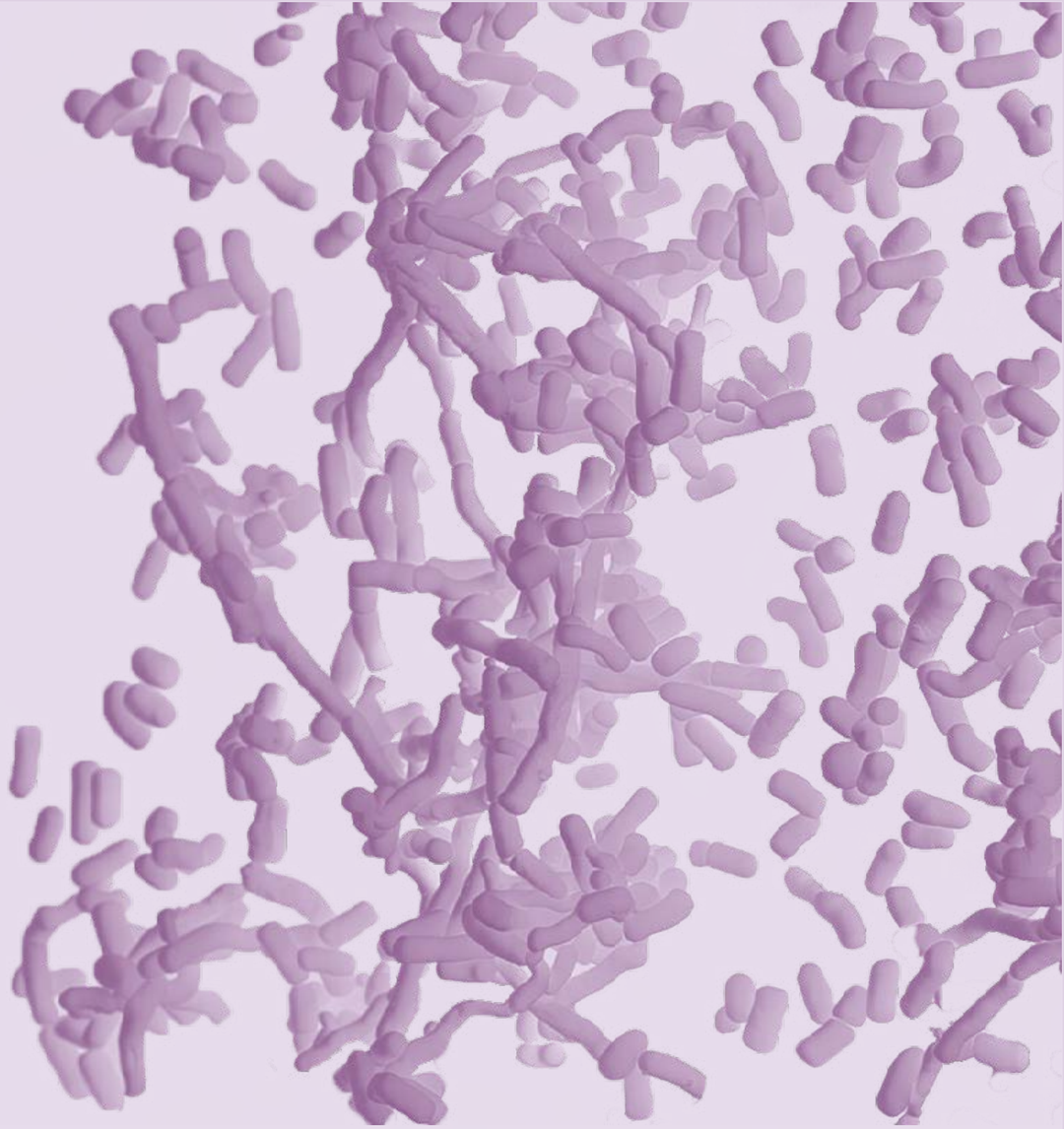
STREPTOMYCES sp.

Breaks down organic matter in the soil[4]

Produces its own antibiotics which has been used by humans to develop streptomycin and other antibiotics[5]

The smell after it rains comes from the molecule geosmin which is released by this genus of beneficial bacteria[2]

Let's give a big thank you to bacteria, as they were the first organisms to photosynthesize and helped create the oxygen-rich environment we know and love. Bacteria put the pro in prokaryote, as this single-celled baddie is the most common life form on the planet. We wouldn't be on planet earth without these little fellas, as they are believed to be the first form of life on Earth.



***Streptomyces* sp.**
https://prints.sciencesource.com/featured/streptomyces-sp-sem-meckesottawa.html

[1]Tankeshwar, A. (2022, July 24). Size of Bacteria: Giant, Smallest, and Regular Ones. Microbe Online. https://microbeonline.com/size-of-bacteria/

[2]Orgiazzi, A., Bardgett, R., Barrios, E., Behan-Pelletier, V., Briones, M., Chotte, J.-L., Deyn, G. B., Eggleton, P., Fierer, N., Fraser, T. D., Hedlund, K., Jeffery, S., Johnson, N., Jones, A., Kandeler, E., Kaneko, N., Lavelle, P., Lemanceau, P., Miko, L., & Wall, D. (2016). Global Soil Biodiversity Atlas. https://doi.org/10.2788/799182

[3]Tankeshwar, A. (2013, May 5). Shapes of Bacteria: Cocci, Bacilli, and Spirochetes. Microbe Online. https://microbeonline.com/characteristics-shape-of-pathogenic-bacteria/

[4]Olanrewaju, O. S., & Babalola, O. O. (2019). Streptomyces: Implications and interactions in plant growth promotion. Applied Microbiology and Biotechnology, 103(3), 1179–1188. https://doi.org/10.1007/s00253-018-09577-y

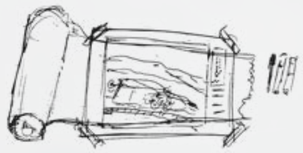
[5]Cuozzo, S., de Moreno de LeBlanc,A., LeBlanc, J. G., Hoffmann, N., & Tortella, G. R. (2023). Streptomyces genus as a source of probiotics and its potential for its use in health. Microbiological Research, 266, 127248. https://doi.org/10.1016/j.micres.2022.127248

DESIGN COMMUNICATION

DESIGN PROFESSIONALS

Landscape Architects

MEDIUM



Concept designs, construction documents etc.

THE PUBLIC

Other design professionals

Contractors

Community Stakeholders

Landscape architects aim to make changes in the world, and one of their main ways of doing that is through the exchange of information, which is achieved through design communication. This is a collaborative process where designers engage in a dialogue with other design professionals, clients, and community stakeholders to bridge gaps and to develop well-informed designs.[1] At the center of this process are the mediums of communication that landscape architects use, such as concept diagrams, construction documents, perspectives, and many more. These different mediums play a critical role in the process of transmission, as landscape architects want to ensure their designs align with the schemes of other design professionals, are actually constructible, and accurately represent the needs of their community stakeholders. Being a design communication project, my master's final project *Microbial Synthesis* follows a similar framework to achieve the goal of representing soil microbiome diversity through the medium of sound, utilizing the process of science communication.

[1]Norouzi, N., Shabak, M., Embi, M. R. B., & Khan, T. H. (2015). The Architect, the Client and Effective Communication in Architectural Design Practice. Procedia - Social and Behavioral Sciences, Contemporary Issues in Management and Social Science Research., 172, 635–642. https://doi.org/10.1016/j.sbspro.2015.01.413

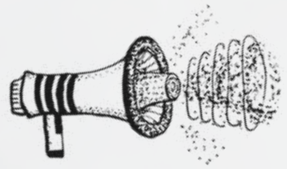
SCIENCE COMMUNICATION

SCIENCE COMMUNICATORS

Asa Conover

Scientists, Journalists, Students Etc.

MEDIUM



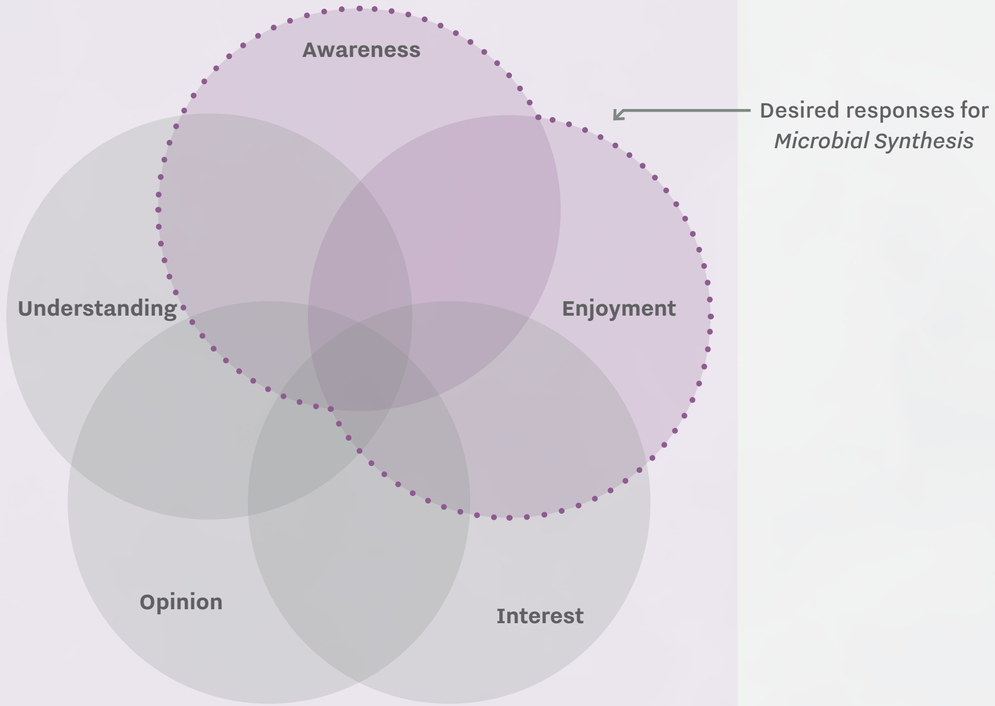
Papers, Media, Activities, Etc.

THE PUBLIC

Scientific Community

Lay Community

PERSONAL RESPONSE TO SCIENCE



SCIENCE COMMUNICATION

The use of appropriate skills, media, activities, and dialogue to produce a personal response to science from the public
(Bryant, 2003; Burns et al., 2003)

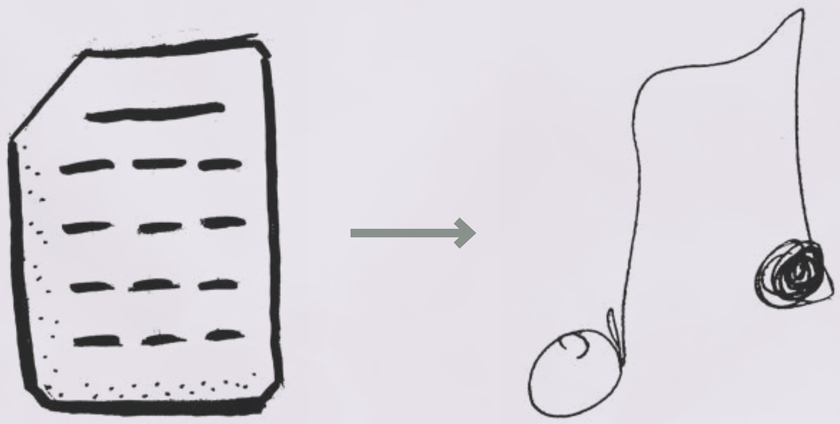
Science communication is the process by which the discipline of science interacts and shares scientific findings with the public which includes other researchers and with lay people.[2] Some typical methods for dissemination are conference lectures or peer-reviewed articles which primarily reach other scientists, as well as through news articles, workshops, and even social media to reach a wider audience.

Using Burns et al.'s (2003) AEIOU definition, the goal of science communication is not to only pass on knowledge, but to elicit a personal response that the authors separate into five distinct groups, awareness, enjoyment, interest opinions, and understanding.[3] *Microbial Synthesis* focuses on two of these groups: Increasing awareness to make the unseen world of microbiology more familiar, and creating enjoyment or other emotional responses of science through experiencing it as an art installation that implements other forms of communication.

[1]Bryant, C. (2003). Does Australia need a more effective policy of science communication? International Journal for Parasitology, 33(4), 357–361. https://doi.org/10.1016/S0020-7519(03)00004-

[2]Burns, T. W., O'Connor, D. J., & Stocklmayer, S. M. (2003). Science Communication: A Contemporary Definition. Public Understanding of Science, 12(2), 183–202. https://doi.org/10.1177/09636625030122004

SONIFICATION



DATA

SOUND

BENEFITS

Represents Complex Systems Well

Increases Accessibility for Visually Impaired

Evokes Emotional Response

DATA SONIFICATION

Data sonification is a science communication technique of transforming data into sound. It has many benefits such as in its ability in representing complex datasets, engaging audiences emotionally, and being accessible for the visually impaired.

Communicating the intricacies of microbiomes can be a challenge in itself, and communicating the complex relationships between ecology, equity and health can be even more difficult.[1] Data sonification, or the auditory representation of data,[2] is an emerging method for science communication that can deepen understanding of complex systems,[3] engage audiences in new ways,[4] and be more accessible for the visually impaired.[5] In general, sound art can evoke curiosity, foster connections, and elicit emotional responses.[6] Microbes can't be seen with the naked eye, so alternative ways to represent them that are better suited for large complex datasets and that engage audiences emotionally are worth exploring.

INTERACTIVITY

BENEFITS

Increases Memory

Erases Line Between Researcher & Participant

Promotes Reflection & Agency

INTERACTIVITY

By emphasizing interactivity, the installation encourages participation and exploration with the data. This can help dissolve the line between research and audience through active engagement.

Microbial Synthesis is attempting to increase awareness and enjoyment even more through its emphasis on interactivity. Interactive sonification invites participants to experience data directly, promoting reflection and agency,[7] and dissolving the line between researcher and audience.[8] Interactivity is powerful approach as it can increase memory[9] and the enjoyment a participant experiences when viewing an art installation.[10] In addition, interactive learning activities have been suggested as a possible opportunity for improving public perspectives on microbes.[11] When combined, data sonification and interaction offer a unique and dynamic way to express the scientific findings of the soil pilot study.

[1] Amin, R., Nath, H., & Amin, R. (2023). Environmental Justice and Education: Bridging the Gap between Ecology, Equity, and Access. Journal of Advanced Zoology, 44, 1075–1082. https://doi.org/10.17762/jaz.v44iS-3.1061

[2] Nees, M., & Walker, B. (2012). Theory of Sonification. In T. Hermann, A. Hunt, & J. G. Neuhoff (Eds.), Principles of Sonification: An Introduction to Auditory Display (pp. 9–39). Logos Publishing House.

[3] Martin, E. J., Meagher, T. R., & Barker, D. (2024). Representing biodiversity decline data by manipulating familiar audio files to create emotional responses: A novel sonification method of soundwave-level deletion. Biological Conservation, 300, 110852. https://doi.org/10.1016/j.biocon.2024.110852

[4] Ricci, K., McLauchlin, B., & Hua, J. (2023). Impact of a Science Art Exhibit on Public Interest and Student Comprehension of Disease Ecology Research. Journal of Microbiology & Biology Education, 24(1), e00162-22. https://doi.org/10.1128/jmbe.00162-22

[5] Arcand, K. K., Schonhut-Stasik, J. S., Kane, S. G., Sturdevant, G., Russo, M., Watzke, M., Hsu, B., & Smith, L. F. (2024). A Universe of Sound: Processing NASA data into sonifications to explore participant response. Frontiers in Communication, 9. https://doi.org/10.3389/fcomm.2024.1288896

[6] Gilmurray, J. (2016). Sounding the Alarm: An Introduction to Ecological Sound Art. Musicological Annual, 52, 71. https://doi.org/10.4312/mz.52.2.71-84

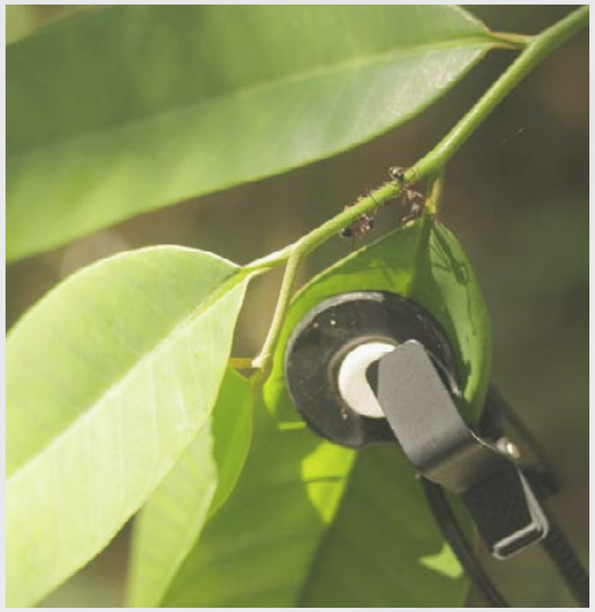
[7] Trilles, S., Granell, C., Degbelo, A., & Bhattacharya, D. (2020). Interactive guidelines: Public communication of data-based research in cities. PLOS ONE, 15(1), e0228008. https://doi.org/10.1371/journal.pone.0228008

[8] Sexton, J. (2007). Music, sound and multimedia: From the live to the virtual. Edinburgh University Press. https://www.jstor.org/stable/10.3366/j.ctt1g0b5k8

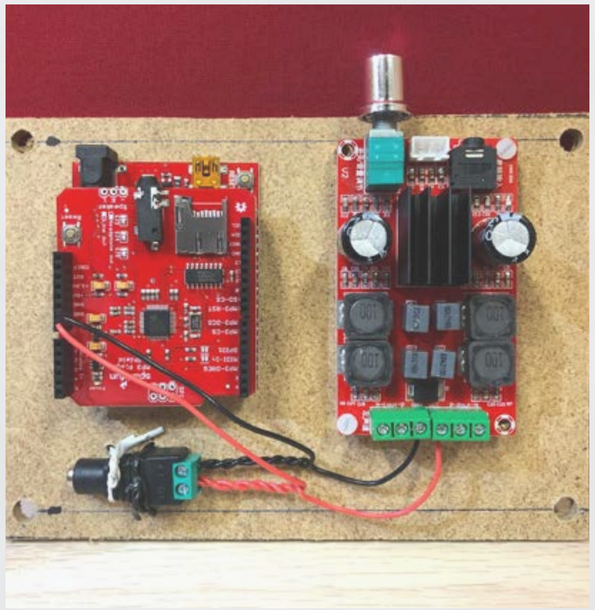
[9] Loszchuk, C. (2020). Why Combining Interactive Installations With Social Justice Art is an Effective Way to Engage Viewers and Make Space for Student Voice and Learning. http://hdl.handle.net/1828/12010

[10] Morreale, F., & De Angeli, A. (2015). Evaluating Visitor Experiences with Interactive Art. Proceedings of the 11th Biannual Conference of the Italian SIGCHI Chapter, CHItaly '15, 50–57. https://doi.org/10.1145/2808435.2808440

SOUNDSCAPES OF SOCIOECOLOGICAL SUCCESSION
Will Bonner, MLA 2023
https://wnb4.com/synesthesia-synthesizer



AMPLIFYING THE TROPICAL ANTS (ATTA)
Dr. Lisa Ann Schonberg, 2017 - Ongoing
https://lisaschonberg.com/Ants



SOUNDSCAPES OF SOCIO-ECOLOGICAL SUCCESSION
Dr. Jon Bellona, 2021
https://www.jpbellona.com/work/soundscapes-of-socioecological-succession/

Microbial Synthesis both physically and conceptually has come into being from connecting with some of the following individuals. UO alumni Will Bonner (MLA 2023) developed *Synesthesia Synthesizer*, a sound installation to communicate how different climatic conditions can overlap to create mega-wildfires.[1] Bonner sonified temperature, wind, and stream height data from the HJ Andrews Research Forest to allow participants to activate multiple switches to hear the different datasets individually and together.

Another influential work was Dr. Lisa Ann Schonberg's PhD dissertation that crossed art and science through an acoustic ecological exploration of ants.[2] Her work was situated in the mass insect population decline as related to climate change, as one of her intentions was to foster a stronger emotional response to insects through sound. She questioned, "What kinds of new and shifting ways of relating can these listening practices bring about?"[2]

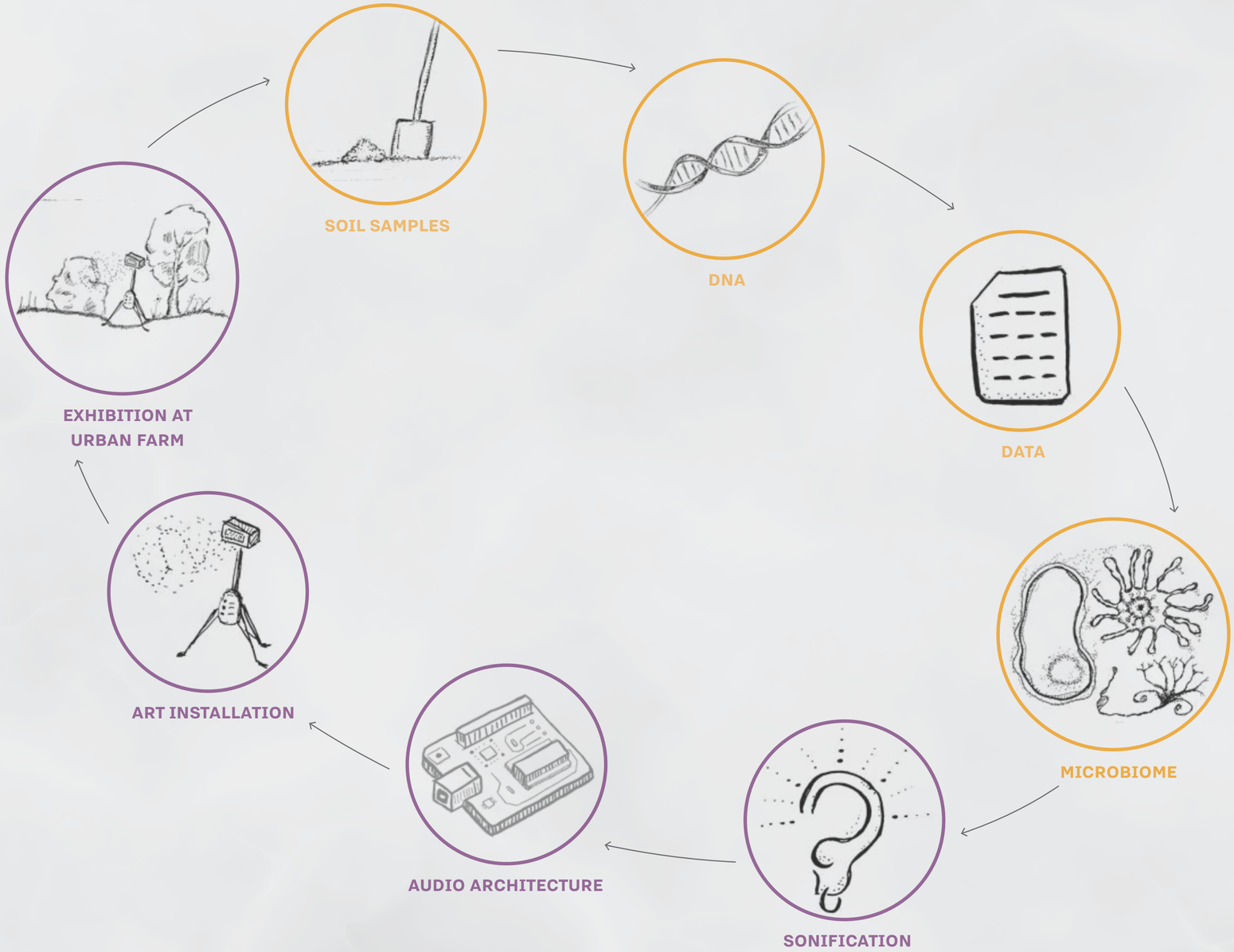
In addition, the works of Dr. Jon Bellona, an assistant professor in Music Technology at the UO, provided a framework for the set-up of *Microbial Synthesis*. Works like *Soundscapes of Socioecological Succession* examined the aftermath of the 2020 Holiday Farm Fire using microcomputers in programmable sound installations.[3] He has been researching the efficacy of data sonification, and has employed user surveys to test the enjoyment of data sonification projects.[4]

[1]Bonner, W. (2023). Synesthesia Synthesizer. Retrieved April 10, 2026, from https://wnb4.com/synesthesia-synthesizer

[2]Schonberg, L. A. (2025). Speculative Ecoacoustic Composition Systems: Listening to Insects Through Music [PhD Dissertation]. Rensselaer Polytechnic Institute. https://files.cargocollective.com/c1440177/SCHONBERG-PHD-DISSERTATION_AUG-2025.pdf

[3]Bellona, J. (2021). Soundscapes of Socioecological Succession. Jpbellona. https://www.jpbellona.com/work/soundscapes-of-socioecological-succession/

[4]Bellona, J., Li, H., Roberts, J., Bower, A., & Smith, L. (2024). Iterative Design of Auditory Displays Involving Data Sonifications and Authentic Ocean Data. Proceedings of the 29th International Conference on Auditory Display (ICAD2024), 11–17. https://doi.org/10.21785/icad2024.002



Microbial Synthesis is heading down an alternative path of conceptualization, by sonifying data. This project began as an experiment to understand a place more deeply, through the Soil Pilot Study of the UFR and WRNA. This process of knowledge generation moved from site to lab to computer, and Microbial Synthesis aims to return the results back to the main users of the site, the students of Urban Farm class, through a field broadcast of the results.

This journey has been circuitous and has had many steps. The resulting microbiome data was transcribed into sound through the audio production software Ableton, with the goal of representing the soil microbial diversity of the UFR & WRNA. To be able to broadcast the produced soundscape, an audio architecture system was created using Arduinos, or microcontrollers, that allow for programmable interactivity. These microcomputers were integrated into *Microbial Synthesis*, an art installation, that was then exhibited at the original Urban Farm to engage the Urban Farm students. The goal of the exhibition was to increase awareness of the soil microbiomes through noticing the sonic changes that result from interacting with an enjoyable installation.

PARAMETER MAPPING

Different taxa levels of the microbiome data were mapped to different audio characteristics

Kingdom → **Wave Form**
The shape of an audio signal over time that provides the basis for the tone of the microbiome soundscape.

Phylum → **Octave**
The range between the a lower and higher version of the same note, dictating the range for possible notes that can be sonified.

Class → **Oscillation**
The variation in the shape of the wav form that gives the tone subtle variations.

Order → **Delay**
Plays back the last note over a period of time creating an effect similar to an echo.

Family → **Sustain**
The duration or length of how long a note is held.

Genus → **Velocity**
The amount of force a note is played, notes with higher velocity will be louder.

Species → **Pitch**
The specific note that is played when sonified.

To turn data into sound, diversity-related aspects of the data were matched with different audio characteristics. For *Microbial Synthesis*, ecological measurements of richness and abundance were used, at each taxonomic level of the microbiome. To demonstrate this, let's use the taxonomic level of species, as species richness relates to the total amount of species found in a certain population while species abundance refers to the amount of individuals per species. [1]

The taxonomic richness and abundance of the data from the UFR and WRNA Soil Pilot Study helped establish the framework for my sonification process and produce a soundscape with level of sonic diversity that reflected the diversity of each microbiome sample. Each taxonomic level was assigned a specific audio characteristic (pitch, volume, sustain e.g.) through parameter mapping, a common sonification approach for large datasets .[2] To begin, each kingdom (bacteria, fungi, archaea & virus) was assigned a unique wave form that is the base sound of the synthesis. The next taxa level, phylum, was used to determine the octave range of the (2 phyla = 2 octaves). Continuing, class was mapped to oscillation, order to delay, family to sustain, genus to velocity, and species to pitch. By sonifying biodiversity to multiple audio characteristics, the resulting soundscape had sonic diversity at multiple levels.

[1] Biogeographic region—Species Richness, Abundance, Diversity | Britannica. (n.d.). Retrieved April 22, 2026, from https://www.britannica.com/science/biogeographic-region/Components-of-species-diversity-species-richness-and-relative-abundance

[2] Grond, F., & Berger, J. (2011). Parameter mapping in sonification. In T. Hermann, A. Hunt, J. Neuhoff, & Europäische Zusammenarbeit auf dem Gebiet der Wissenschaftlichen und Technischen Forschung (Eds.), The sonification handbook. Logos Verlag.

STEP SEQUENCER
The abundance and richness of at each taxa level was used as the input data into the plugin, which operates similar to step sequencer.

To be able to map the different taxonomic levels to different sound parameters, the Digital Audio Workspace (DAW) Ableton Live 12 was used.[1] This is a music production software program that has different plugins and effects to support audio creation and mixing. To perform the data sonification the plugin Manifest Audio Sonification was used, which allows data from a .csv file to be imported and mapped to different audio characteristics.[2] The flexibility of this plugin allowed for the importation of the richness and abundance of the microbiomes from the Soil Pilot Study dataset, and enabled their application to modulate the audio characteristic they were mapped to.

The Manifest Audio Sonification plugin interprets the input data and sonifies it in a similar way to a step sequencer. A step sequencer works by dividing a measure of music into a number of steps of different values which can be linked to modify different sonic qualities. This mapping can be imagined as a histogram plot, with the richness of the specific taxa-level on the x-axis represented by the number of sub-dividing steps, and abundance on the Y-axis which determines the value of each step. This process was conducted for the railroad samples as they had a slightly higher diversity level when compared to the other samples site, and was conducted for four microbial groups, bacteria, fungi, archaea & virus, resulting in a total of four soundscapes.

[1] Ableton Live 12. (n.d.). Ableton. Retrieved April 23, 2026, from http://www.ableton.com/en/live/

[2] Sonification Bundle. (n.d.). Manifest Audio. Retrieved April 23, 2026, from https://manifest.audio/

MICROBIAL SYNTHESIS

① Speaker Box

Containing a small mobile amp, the Speaker Box that enables the installation to broadcast the microbiome soundscapes.

② “The Brains”

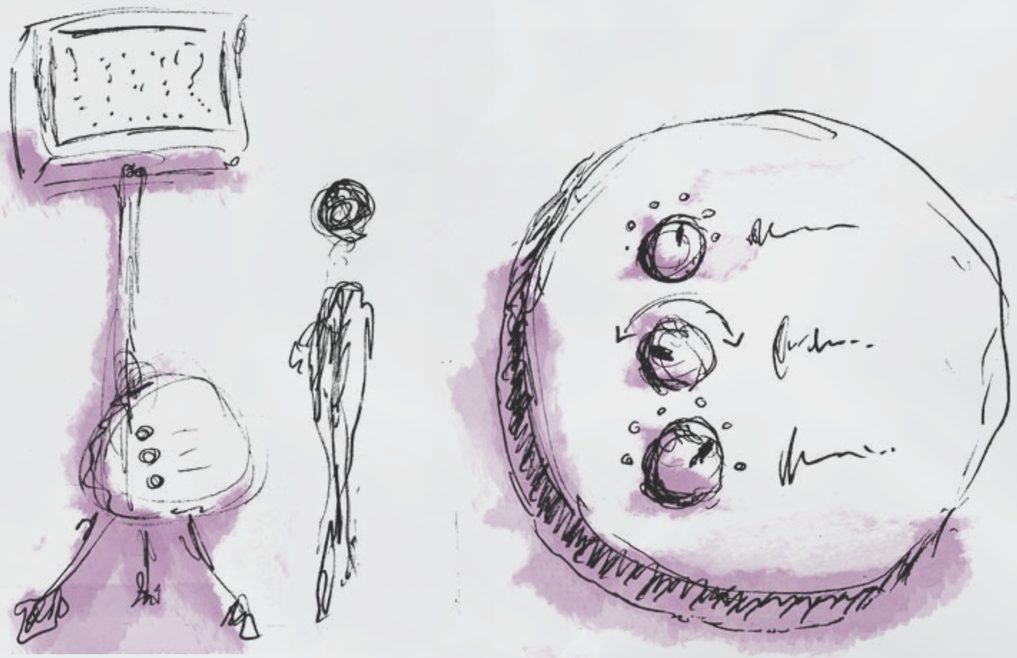
Housing the microcontrollers, “the Brains” is the location of where all the electronics connect.

③ Control Panel

With switches on full display, the Control Panel is the interactive element allowing for the soundscapes to be triggered.

CONCEPT SKETCHES

Early conceptual sketches of what *Microbial Synthesis* might look like



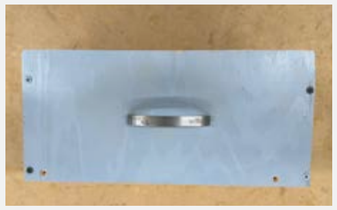
HOW'S THE WEATHER UP THERE?

One of the main inspirations for the form of the art installation was a mobile weather station.

Ryan Perry

The design of the physical installation was based off mobile weather stations, as they provide a reading of the local conditions of the environment. The tripod base provides a simple yet interesting form that can be easily moved and set up, while still being stable and strong enough to be set up in almost any setting. The weather station stand also provides an easy way to attach a variety of external components like a control panel, speaker array and other environmental sensors using off-the shelf brackets and other mounts.

① Speaker Box



CAN YOU HANDLE THIS?

An old drawer handle gives the ease of portability to the speaker box.

CENTRIFUGE

The speaker grills are reused plastic test tube-holding rings from a 1995 Beckman GPR Centrifuge

LAND LAB ART INSTALLATION

Collaboration with Liam Sobie, 2024
Materials were reused from this past installation for *Microbial Synthesis*

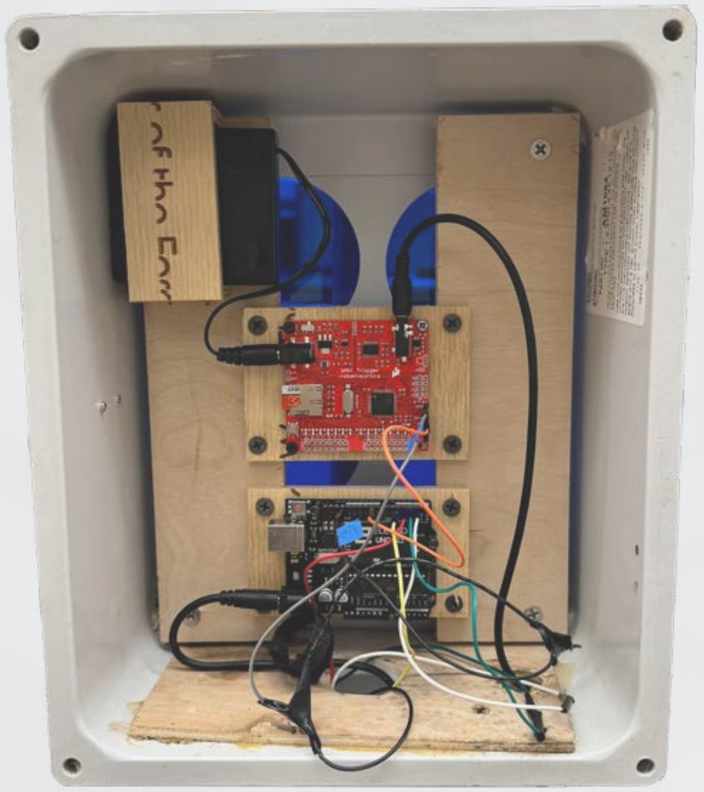
The materials of the installation embrace the decompositional function that many soil microbes exhibit by reusing some common tools used in microbiology as well as materials from one of my past art installations. The speaker cabinet incorporates pieces from a Beckman GPR Centrifuge from 1995, as the speaker grills. Another component, the diversity knob, reuses another piece element from a centrifuge, the spinning rotor that holds the test tubes.

The installation's synthesis of existing materials can be understood through the concept of bricolage, or the art of making-do. Coined by anthropologist Claude Levi-Strauss, bricolage is the process of using, "whatever is at hand"... [to address oneself] to a collection of oddments left over from human endeavors" (pg. 17-19).[1]

Many of materials that make up this installation are reused from an earlier sound installation collaboration with Liam Sobie from Spring of 2024. Many art installations are temporary and often are just stored somewhere indefinitely and are never set up again. The UFR and WRNA is itself a bricolage landscape, a blend of riparian forest, gravel mine, and transplanted orchard. Similarly, *Microbial Synthesis* is an assemblage of soil microbiome data, old lab equipment, my past, and new skills.

[1] Lévi-Strauss, C. (1966). The savage mind. The University of Chicago Press.

② “The Brains”



AUDIO COMPONENTS LAYOUT

The design of the of the audio microcomputer system.

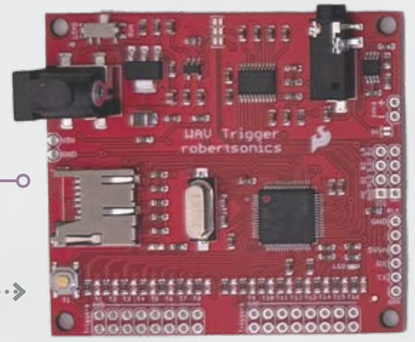
Microbiome Taxa Switches

Arduino UNO R3 Microcontroller

Battery Packs

Roland Cube Speaker

Micro SD Card



WAV Trigger Microcontroller

22 AWG Wire
3.5mm Audio Cable
Barrel Power Supply Cable
Internal Connection

To broadcast the soundscapes, an “audio architecture” system was designed using Arduino microcontrollers as they are small, affordable, and use an opensource platform that allows computer code to be written and uploaded to the Arduinos to perform specific functions, in this case audio playback.[1] These were stored in an out of commission databox from scientific fieldwork, providing protection from the elements as well as easy access to the electronic components.

The audio architecture of *Microbial Synthesis* uses two types of Arduinos, a Wav Trigger and Uno R3. The Wav Trigger is the microcontroller where the soundscapes were uploaded to through a micro-SD card, has the function of triggering the different soundscapes, but cannot start multiple tracks simultaneously. This is where the Uno R3 comes in, as it can dictate commands to the Wav Trigger that it cannot do on its own. The code that was uploaded to the Uno R3 was written to play all four tracks on the Wav Trigger instantly at start up, and the external switches actually function as a mute button. This was designed in this way to enable all four soundscapes to be in-sync when interacted with, allowing users to hear the soundscapes individually or in any combination.

[1] Shaikh, M. (2012). Arduino Tool: For Interactive Artwork Installations. CoRR, abs/1202.1953. https://doi.org/10.48550/arXiv.1202.1953

③ Control Panel

CONTROL PANEL
By interacting with the control panel, participants are able to trigger the different microbial soundscapes and apply effects.

To make the data into something that visitors could interact with, a series of four triggerable switches were installed into the control panel to activate one of soundscapes for the four microbial kingdoms. [ES20.1]The design of the control panel was simple, as it focused on four big switches that are satisfying to flip, to increase accessibility and encourage interaction. Like the speaker box, the wooden materials of the control panel are a bricolage from the past collaborative sound installation with Liam Sobie, with new vinyl letters adhered to it for labels.

FUTURE DIRECTIONS

Microbial Group:

VIRUS

Domain:

Virus

Size:

5 to 300 nm[1]

Taxonomically has been placed outside the realm of life, as virus's don't reproduce in their own cells.[2]

They reproduce by inserting their genetic code into a host cell's DNA to create copies of the virus. This transfer of genetic material can encourage evolution. [2]

May have been one of the original life forms on planet Earth, but it is unclear as they do not fossilize.[3]

Spotlight Microbe:

LAMBDA PHAGE

A bacteriophage, or specialized virus that targets specific bacteria cells.[4]

Lambda phage targets *Escherichia coli (E. coli),* and the studies in the mid 20th century on this relationship has given critical insights on gene transfer and reproduction.[4]

Viruses are probably the most misunderstood of the bunch. They are technically not in the taxonomic realm of life, but in the realm of non-living, because they don't reproduce in their own cells. Rather they infect other microbes and transfer their own DNA into host's genetic code, which causes their host to reproduce copies of the virus. This trait can cause them to spread rapidly, like covid 19, but it is also important in the process of evolution as it increases genetic diversity. There are viruses called bacteriophages that target pathogenic microbes both in the soil and on our skin, playing a critical role in health and keeping microbiomes balanced.

https://doi.org/10.1007/10_2009_7
https://doi.org/10.1007/s13205-024-04101-8

[1]Kaiser, G. (2016, March 8). 10.2: Size and Shapes of Viruses. Community College of Baltimore. Biology LibreTexts. https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(Kaiser)/Unit_4%3A_Eukaryotic_Microorganisms_and_Viruses/10%3A_Viruses/10.02%3A_Size_and_Shapes_of_Viruses

[2]Orgiazzi, A., Bardgett, R., Barrios, E., Behan-Pelletier, V., Briones, M., Chotte, J.-L., Deyn, G. B., Eggleton, P., Fierer, N., Fraser, T. D., Hedlund, K., Jeffery, S., Johnson, N., Jones, A., Kandeler, E., Kaneko, N., Lavelle, P., Lemanceau, P., Miko, L., & Wall, D. (2016). Global Soil Biodiversity Atlas. https://doi.org/10.2788/799182

[3]Sanjuán, R., Nebot, M. R., Chirico, N., Mansky, L. M., & Belshaw, R. (2010). Viral Mutation Rates. Journal of Virology, 84(19), 9733–9748. https://doi.org/10.1128/JVI.00694-10

[4]Casjens, S. R., & Hendrix, R. W. (2015). Bacteriophage lambda: Early pioneer and still relevant. Virology, 0, 310–330. https://doi.org/10.1016/j.virol.2015.02.010

Coming full circles signals that this phase of the MLA master's final project is done, and is resynthesizing into a new research opportunity. With the support from the Center for Science Communication through their Small Grant research grant, the next step in this research project is investigating the efficacy of data sonification as a communication tool, particularly in transmitting microbiological data. This next phase of research tests the response to the installation using pre- and post-surveys with a group of college students. The results from these surveys will then be analyzed to determine if there was a change in microbial awareness or if the installation was enjoyable. These results will be presented at the Center for Science Communications Research Forum, as well as written as a research paper to be published in an academic journal.

PRE-SURVEY

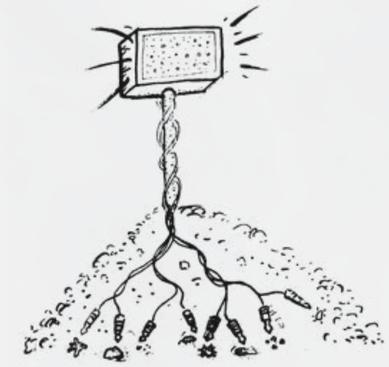
Late April 2026
Students take survey before interaction with exhibition

PRE-SURVEY TOPICS

- **Urban Greenspace**
- **Microbial Awareness**
- **Connection with Nature**

EXHIBITION

Late May 2026
Students interact with exhibition



POST-SURVEY

Late May 2026
Students take an additional survey after interaction with

POST-SURVEY TOPICS

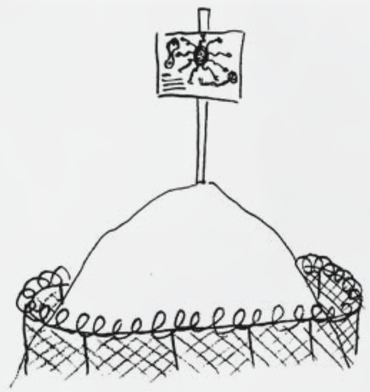
- **Urban Greenspace**
- **Microbial Awareness**
- **Connection with Nature**
- **Exhibition Enjoyment**

RETURNING TO THE ROOTS

To complete the cycle, *Microbial Synthesis* was set up for a field broadcast to the Urban Farm Class

Images from Grace Youngblood's Thesis 2022

Photos from Grace Youngblood's Thesis 2022



Clark Frauenglass

In the end of April 2026, I visited the Spring 2026 Urban Farm classes, introduced my project, and distributed a voluntary online pre-survey through Qualtrics with questions that were intended to obtain a baseline understanding of the students awareness and preconceptions of microorganisms, urban greenspace, and connection to other life forms (Appendix A).

The Urban Farm classes was selected as the participant group for this experiment, as this class has a direct connection with the UFR & WRNA, has a large class size, as well as that recent studies have shown that college students mischaracterized microbes as primarily being associated with disease.[1] The class draws in students from across many different majors and age ranges, and their curriculum of the Urban Farm class touches on the role of soil microbes in agriculture production.

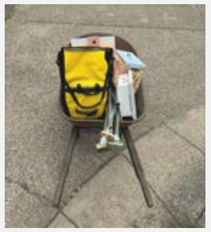
Out of the close to one hundred students in the two Urban Farm classes, the pre-survey received 39 responses, or around 40% of the class. A month later, I returned to the class in late May, performed a field broadcast of *Microbial Synthesis*, and distributed the accompanying post-survey. The post-survey received less responses than the pre-survey, with just 27 or about 25% of the class (Appendix B).

[1] Lane, A. R., Momsen, J. L., & Wiltbank-Chau, L. B. (2025). Positive microbiology: Addressing students' knowledge gaps regarding the benefits of microorganisms. Journal of Microbiology & Biology Education, 26(2), e00045-25. https://doi.org/10.1128/jmbe.00045-25

BROAD-CAST

The first iteration of *Microbial Synthesis* was exhibited to students in the Urban Farm class

Photos courtesy of Liam Sobie



ROUND II

The second exhibition of *Microbial Synthesis* was broadcasted at the Grove Garden, a student ran community garden on campus.

The exhibition was set up at the edge of the original Farm to be close to the students working and escape the cacophony of the broken dust exhaust unit for the Millrace Furniture Studio. The exhibition started with an informal conversation with the students about each microbial group included in the study. The field broadcast then commenced, listening to one microbiome soundscape at a time, and layering each track on top of each other. Afterwards, students were then asked to take the post-survey.

The initial takeaway from the Urban Farm exhibition was how *Microbial Synthesis* opened conversations and opportunities. Many students and some passersby stopped and chatted with me about their interests in microbes, music, and art. From this field broadcast I was asked if *Microbial Synthesis* could be the subject of a student's monthly zine, and one of the coordinators of the Grove Garden, a student-ran community garden on campus, asked if I could exhibit the installation at their end of the year garden party. This led to Microbial Synthesis's second exhibition, where students jammed with the soundscapes and led to another invite for *Microbial Synthesis* to be exhibited as part of a musicians set for Eugene's Difficult Music Ensemble's Ambient Ecologies music series.

MAKING MORE FOLKS AWARE

Results of the survey will be presented at the SCR annual research forum in February 2027
https://scr.uoregon.edu/events/

UNIVERSITY OF OREGON'S SCHOOL OF JOURNALISM & COMMUNICATION
CENTER FOR SCIENCE COMMUNICATION RESEARCH FORUM

THE RESULTS ARE IN

The intention is to publish the results in a journal like science communication
https://journals.sagepub.com/home/scx

For the analysis process, the pre- and post-surveys will be linked using the last four digits of the students' Duck ID, to see if there are any changes or trends that happened before and after interacting with Microbial Synthesis, with additional cross analysis to see if factors like demographics, familiarity with microbiology, or greenspace exposure may have influenced any changes.

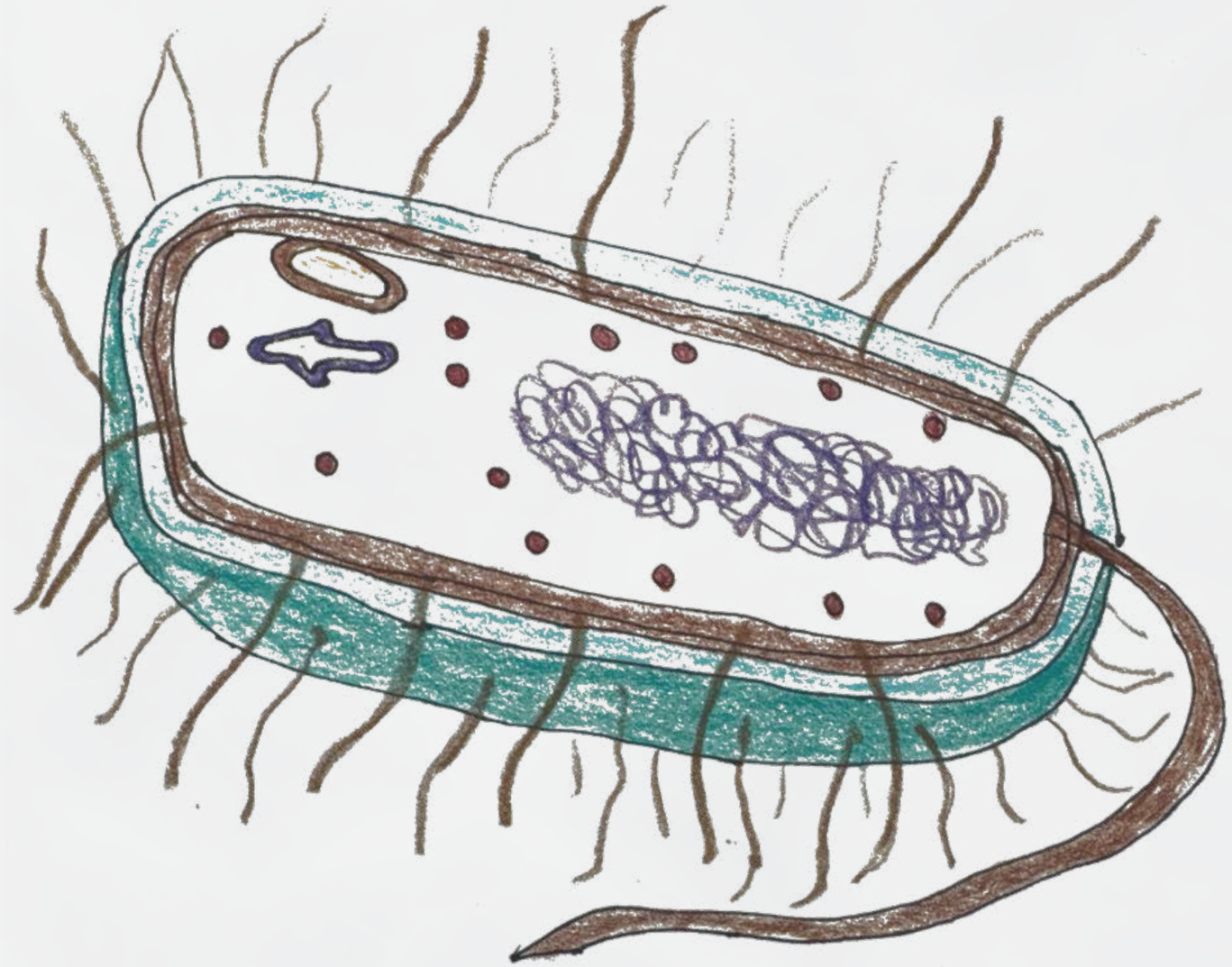
The data for these surveys are still in the early stages of analysis, and once completed, will be presented at the SCR Research Forum as a research poster. At the forum I will have opportunities to discuss my project and the results with science communication researchers as well as other Small Grant recipients, with the hope of one last exhibition of Microbial Synthesis. The other intention with this research is to write a peer-reviewed paper, however, as the pre- and post-survey had a low number of responses, there may not be enough conclusive evidence.

FUNGI
Derrick Mitchell

FUNGI
Estella Dehnert

The many weaving threads of this presentation are like mycelium, the dense and complicated network of small strands that fungi use to spread and move through soil. Microbial Synthesis demonstrates that science communication can help use notice the entangled webs we exist in through raising awareness.

By listening, enjoyment can be cultivated towards the unknown, in this case soil microbiomes. This allows for an entry point into microbiology, which can be inaccessible to those who don't have a strong background with the subject. By raising awareness, the misconception that microorganisms are dangerous and need to eradicated can start to be dismantled, allowing for new openings in the way we conceive microbes and their role in our lives.



ARCHAEA
Dorissa Mitchell

ARCHAEA
Janet Walker

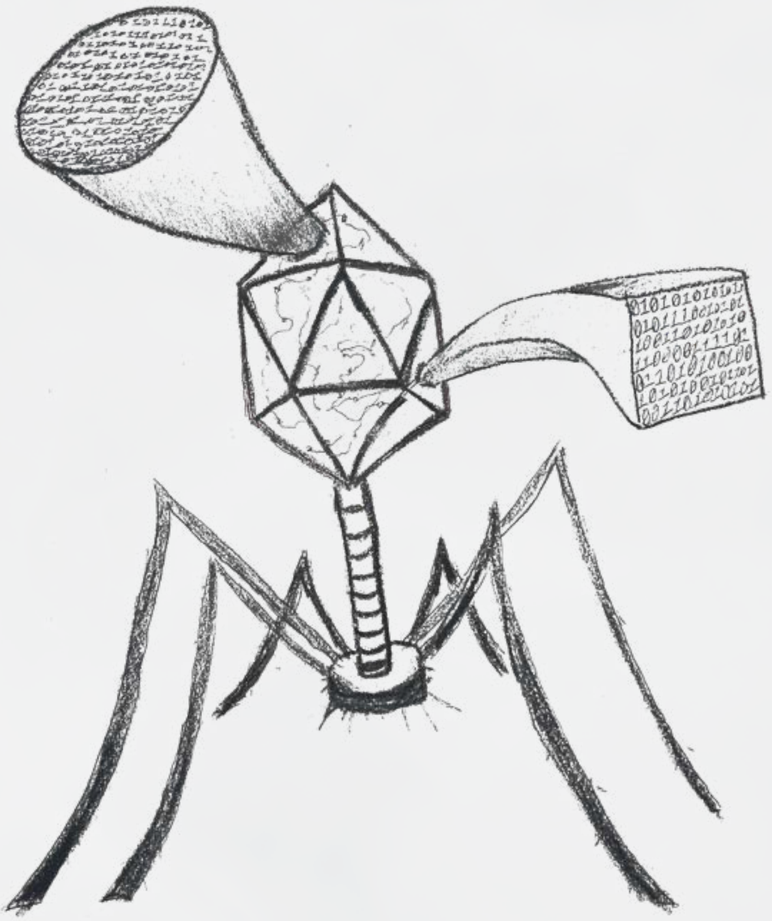
Urban brownfields reflect the ugly truth that our past actions have polluted not only our world, but the many unseen worlds of other organisms. Like archaea, however, life can find a way in extreme conditions and help remediate the past. The sonified microbiome from the Urban Farm Riverside and Willamette River Natural Area still demonstrated that there is a world of dynamic life in what appears to be a forgotten space. As this site is transformed into an agricultural learning hub and restored natural area, there is an opportunity to conceptualize how the microbiome changes through sonification. A potential next step for this research project could be a longitudinal sonification study where the process described in this booklet is repeated to create a new set of soundscapes once the UFR & WRNA are established. This would allow for a sonification comparison study that would gauge how participants' awareness changes after listening to both the pre- and post- restored microbiomes.

BACTERIA
Janet Walker

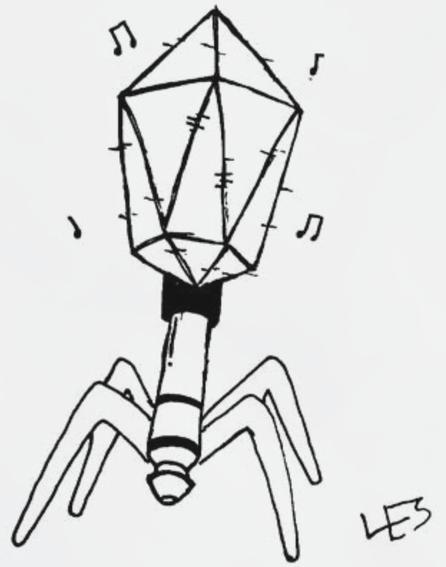
BACTERIA
Samantha Mitchell

As designers of urban greenspaces, landscape architects must balance many different goals of making public spaces that are accessible, meet community needs, provide ecological benefits, as well as being aesthetically pleasing. Ecological-oriented designs have had a higher emphasis over the last few decades in the field, layering biodiversity into design features like green infrastructure and planting plans. This focus overlaps with one of the original intentions of landscape architecture to create health promoting urban landscapes. As the Biodiversity and Old Friends Hypotheses demonstrate, biodiverse landscapes are salutogenic landscapes, and is one more reason that landscape designs should emphasize diversity.

VIRUS
Janet Walker



VIRUS
CJ Schmider



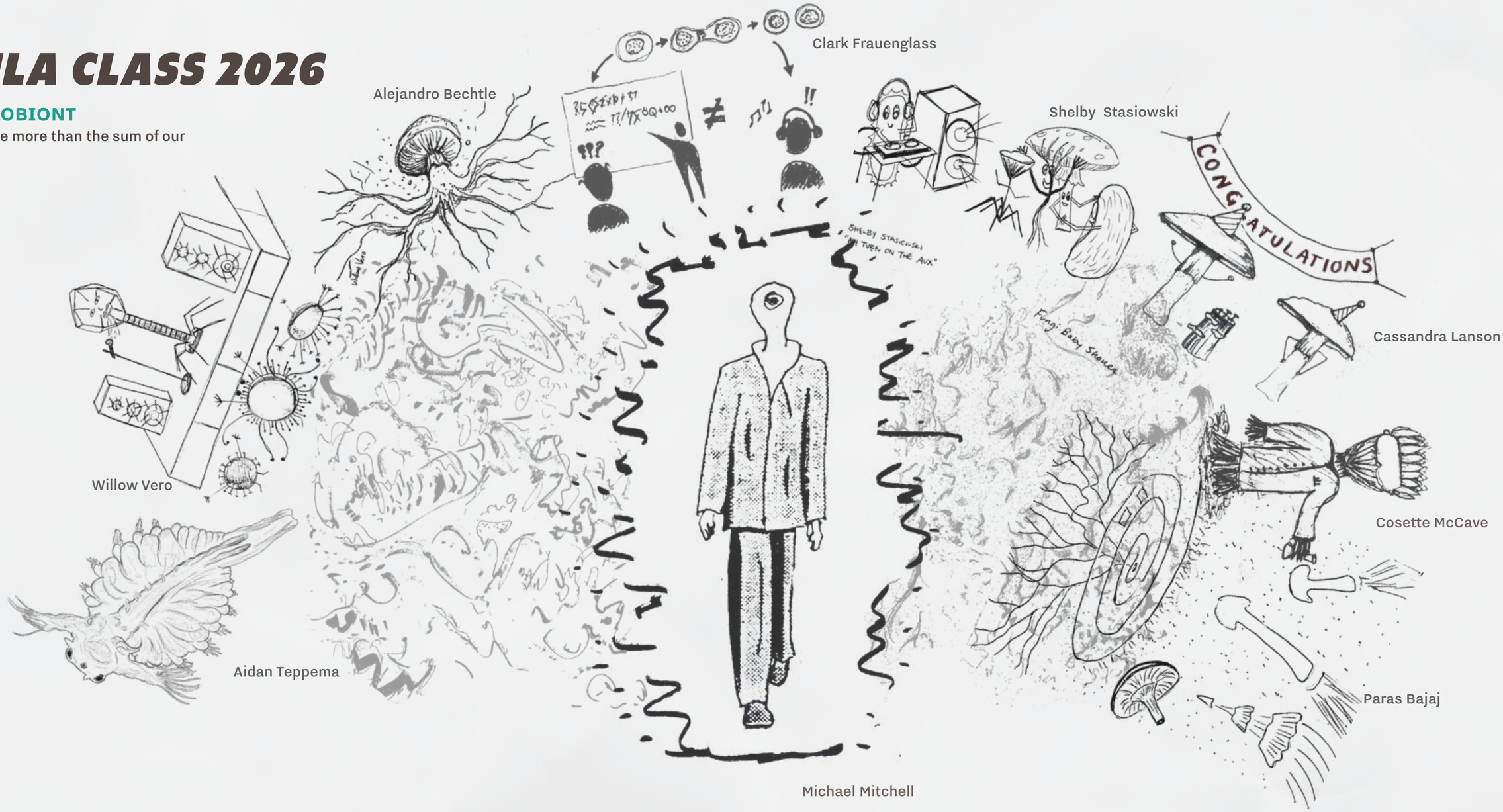
VIRUS
Liam Sobie

As designers, we don't need to be microbiologists, but having this awareness can help us collaborate with scientists and other experts. Like the virus's ability to transfer genetic material, exchanging ideas can change the DNA of our design decisions, reorienting towards a healthier built environment. Awareness is the first step to making a change in the world, and multi-discipline and multi-species collaborations can allow landscape architects to make informed decisions about how the potential impacts their designs may have.

MLA CLASS 2026

HOLOBIONT

We are more than the sum of our parts



Awareness is like a seed, and hopefully, the seed of microbial awareness was sown and germinated through reading this booklet, and if not that's okay. You may never design for microbes specifically, but you may be now more aware that microbes play a critical role in human health. You may never hear another sonification, but you may rethink the way that we perceive data.

You may notice the entangled webs you exist in, how you make do through bricolage, and to quote Sandor Ellix Katz begin to see that: "Our existential context is a microbial matrix. We are continually learning more about how critically important the vast microbial populations everywhere are... Forms of life are not bad or good; we exist in all our co-evolved complexity, a vast matrix of intertwining life-forms at different scales, interacting, mutually coexisting, and feeding off one another, in ways we are just beginning to recognize." [1]

[1] Katz, S. E. (2020). Fermentations as Metaphor. Chelsea Green Publishing.

PRE-SURVEY QUESTIONS

1) Background Information

What is your gender?
- Male
- Female
- Non-binary / third gender
- Prefer not to say

What is your highest education level?
- Some High School / GED
- Graduated High School
- Some College
- Undergraduate Degree
- Graduate Degree

Are you an undergraduate or graduate student?
- Undergraduate
- Graduate

What are the last four digits of your student ID (starts with #95)

What year are you in your program?

What is your major or field of study?

2) Microorganisms

Please self-rate your knowledge of microbiology
- No knowledge (What's a microbe?)
- A little knowledge
- Some knowledge
- A lot of knowledge
- Expert knowledge (I could teach a class on microbiology)

Using a likert scale, please indicate your level of agreement (strongly agree, agree, neither agree or disagree, disagree, strongly disagree) with the following statements (adapting some questions from Abu-Hamaidan et al. 2021) regarding your awareness of microbes. Mark the most accurate statement on the scale below.

Most microorganisms in the world cause disease for humans

My lifestyle choices are affected by my awareness of microorganisms in the environment

The presence of microorganisms in the soil can be beneficial to humans

The presence of microorganisms on plants can be beneficial to humans

The presence of microorganisms in the air can be harmful to humans

The presence of microorganisms on other organisms can be harmful to humans

Please indicate your level of agreement with the following statements (adapting questions Lane et al 2025) regarding your feeling of microbes. **What are the effects of bacteria, viruses, fungi & archaea on people or other living things?** ***Mark the most accurate statement on the scale below.***

Bacteria are
- Always bad
- Usually bad
- Sometimes good & sometimes bad
- Usually good
- Always good
- **Unsure**

Viruses are
- Always bad
- Usually bad
- Sometimes good & sometimes bad
- Usually good
- Always good
- Unsure

Fungi are
- Always bad
- Usually bad
- Sometimes good & sometimes bad
- Usually good
- Always good
- Unsure

Archaea are
- Always bad
- Usually bad
- Sometimes good & sometimes bad
- Usually good
- Always good
- Unsure

3) Urban Greenspace

Urban greenspaces are open areas of the city that are covered with vegetation and typically open to the public. How many are within a 1/4 mile (15-miute walk) of where you live?
- None
- One
- Two
- Three
- Four or more

Please select all the urban greenspaces you know of that are within a 15 minute walk (1/4 mile) of where you live:
- Park
- Natural Area
- Sports Field
- Cemetery
- Farm
- Greenspace not listed

How important is it for you to live near (within a ¼ mile) urban greenspace?
- Extremely unimportant
- Somewhat unimportant
- Neither important nor unimportant
- Somewhat important
- Extremely important

How often do you visit an urban greenspace? Select the answer the best fits.
- Everyday
- Multiple times a week
- Once a week
- Once a month
- Once a year
- Never

With your best guess, please rank at the level of biodiversity of the urban green space you visit the most frequently.
- No biodiversity
- Little biodiversity
- Some biodiversity
- High biodiversity
- Very high biodiversity

With your best guess, please rank the level of health of the urban green space you visit the most frequently.
- Very healthy
- Healthy
- Neither healthy nor unhealthy
- Unhealthy
- Very unhealthy

4) Emotional Connection

Please indicate your level of agreement (strongly agree, agree, neither agree or disagree, disagree, strongly disagree) with the following statements adapted from Mayer & Frantz 2004 Connectedness to Nature Scale. Please answer how you honestly feel.

I often feel a sense of oneness with the natural world around me.

I often feel a kinship with microorganisms.

I have a deep understanding of how my actions affect the natural world.

I have a deep understanding of how the natural world affects my health.

Like a tree can be part of a forest, I feel embedded within the urban ecosystem.

When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.

I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.

My personal welfare is independent of the welfare of the natural world.

POST-SURVEY QUESTIONS

1) Background Information

What is your gender?
- Male
- Female
- Non-binary / third gender
- Prefer not to say

What is your highest education level?
- Some High School / GED
- Graduated High School
- Some College
- Undergraduate Degree
- Graduate Degree

Are you an undergraduate or graduate student?
- Undergraduate
- Graduate

What are the last four digits of your student ID (starts with #95)

What year are you in your program?

What is your major or field of study?

What is your vision condition?
- Normal sighted or corrected-to-normal (e.g., glasses, contacts, surgery)
- Low vision
- Blind

What is your hearing condition?
- Normal hearing
- Hearing loss

2) Microorganisms

Please self-rate your knowledge of microbiology
- No knowledge (What's a microbe?)
- A little knowledge
- Some knowledge
- A lot of knowledge
- Expert knowledge (I could teach a class on microbiology)

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- Always bad
- Usually bad
- Sometimes good & sometimes bad
- Usually good
- Always good
- **Unsure**

Viruses are
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- Usually bad
- Sometimes good & sometimes bad
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- Always good
- Unsure

Fungi are
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With your best guess, please rank the level of health of the urban green space you visit the most frequently.
- Very healthy
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- Neither healthy nor unhealthy
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- Very unhealthy

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I have a deep understanding of how the natural world affects my health.
Like a tree can be part of a forest, I feel embedded within the urban ecosystem.
When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.
I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.
My personal welfare is independent of the welfare of the natural world.

5) Sound Installation Experience

Please indicate your level of agreement (strongly agree, agree, neither agree or disagree, disagree, strongly disagree) with the following statements using the BUZZ scale from Tomlinson et al 2018 regarding your experience with the sound installation:

The sounds were helpful.
The visuals were helpful
The sounds were interesting.
The interactivity was engaging
The sounds were enjoyable.
The sounds were easy to understand.
The sounds were relatable to their ideas.
It was easy to match these sounds to their meanings.
It was difficult to understand how the sounds changed from one variable to the next.
It was fun to listen to these sounds.
It was fun to interact with the installation
It was boring to listen to these sounds.
It was confusing to listen to these sounds.