Chapter 5

Communicating microbiology through art and outreach activities

Eclipse in a petri dish

A fire is born in molten light,
Two microbes weave their fates in sight.
A golden sun, alive and bright,
The spark that sets my path right.

Its center swirls, a world untold,
A story waiting to unfold.
Rays reach out, both sharp and wide,
Like questions pulling from inside.

Then drifts a shadow, calm yet bold,
A silent moon, a tale retold.
The first of many steps to be,
A journey shaped by what I see.

Communicating microbiology through art and outreach activities

Authors contributions

I performed the outreach and science communication activities. I created the figures and wrote the text, Yolanda corrected it.

Abstract

Microbiology plays a crucial role in various aspects of life, and effective science communication is essential to ensure that research has a meaningful societal impact. This chapter explores the intersection of microbiology and public engagement by transforming microscopy images into art and organizing interactive workshops for diverse audiences. These initiatives aimed to foster a greater appreciation for microbial diversity and its significance. The projects described in this chapter facilitated accessible science communication, enhancing public understanding of microbiology. This approach underscores the value of integrating scientific research with creative communication strategies to bridge the gap between scientists and the public.

Introduction

Each chapter of this thesis is introduced with an artistic representation of its scientific content. Throughout my Ph.D., microscopy images have served as valuable tools for science communication and outreach.

Microbial literacy among the general public is crucial, as microbes influence nearly all life on Earth, including humans. They play essential roles in health, contributing to the discovery of new medicines and vaccines, as well as in agriculture by enhancing crop yields and food security and are integral to environmental health, clean water systems, and ecosystem stability [1–4]. The importance of effective science communication became particularly evident during the COVID-19 pandemic, when misinformation, public mistrust of scientists, and ineffective communication strategies hindered public health responses [5–8]. Similarly, public engagement is vital in addressing issues such as antibiotic resistance, which arises from misuse, and declining vaccination rates in certain regions of the world [9].

Interactive tools such as microbiology-themed games have demonstrated potential in fostering scientific understanding. Board games [10], card games [11], and video games, such as the NCCR Microbiomes Game [12], have been developed at the University of Lausanne to engage players and enhance their comprehension of microbiological concepts.

Museums also play a pivotal role in science communication by attracting diverse audiences and enhancing public understanding of scientific topics in an accessible manner [13, 14]. A notable example is *ARTIS-Micropia* [15], a museum in Amsterdam that presents a compelling narrative on the history, diversity, and applications of microbes. Similarly, the Musée de la Main in Lausanne, in collaboration with NCCR Microbiomes, has launched the exhibition *Invisible, la vie cachée des microbes* [16] to highlight microbial life.

Direct engagement with students through classroom visits and workshops provides an opportunity to make microbiology more tangible. Hands-on activities, have been shown to increase children's interest [17] and enhance their understanding of microbial life [18]. These interactive experiences make abstract scientific concepts more accessible while familiarizing participants with laboratory techniques and the real-world impact of microbes.

Several educational programmes have been developed to provide accurate and accessible microbiology resources tailored to children [19, 20]. In addition, science outreach initiatives benefit both students and scientists, as they improve the ability of researchers to communicate their work effectively [21]. Beyond the classroom, microbiology outreach can extend to diverse audiences, including incarcerated individuals [22].

Citizen science projects further engage the public in microbiological research. The Isala project, for example, involved 3,345 women in Belgium in the analysis of the vaginal microbiome [23, 24], and is now expanding to other parts of the world. Similarly, another initiative explored microbial diversity in sourdough bread starters, leveraging the surge in home baking [25]. Such initiative are beneficial for both scientists getting access to valuable data and for the public, discovering and learning high quality information about their own microbiomes.

Finally, the intersection of microbiology and art offers a compelling avenue for science communication. Incorporating visual art into microbiology laboratory courses has been shown to boost students' confidence [26], while events integrating art and microbiology have enhanced understanding and increased participation from under-represented groups [13].

As part of my contribution to science communication, I have showcased microscopy images in art exhibitions, delivered public lectures, and organized workshops throughout my Ph.D. (Figure 5.1). These efforts, described in this chapter, aim to bridge the gap between scientific research and public understanding.

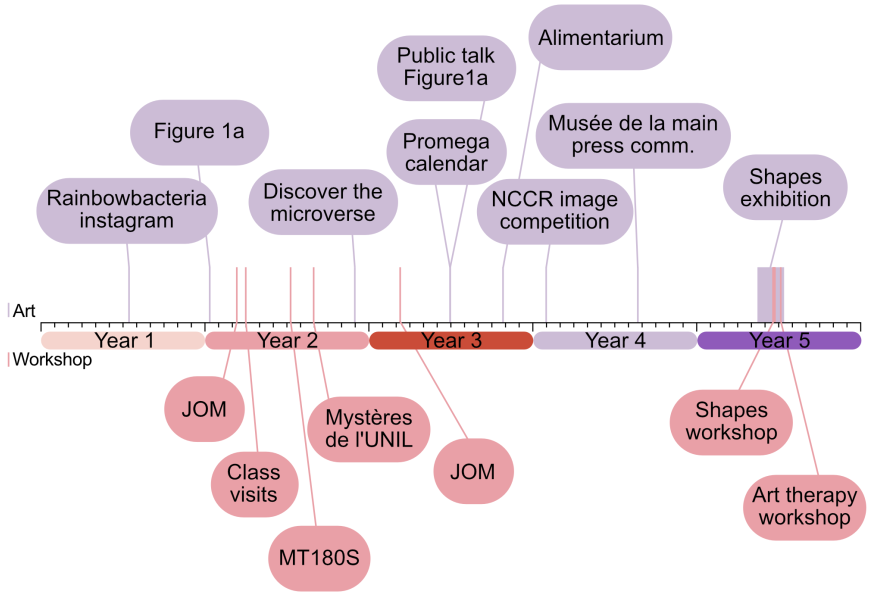

Figure 5.1: A timeline of my PhD, with different events that I have taken part in or organized. On top (purple) are art related events, where the main support was microscopy images. On the bottom (pink) are workshops or public talks.

Using scientific art as a tool to engage with the public

At the beginning of my PhD, as I learned to use a microscope, I was immediately struck by the beauty of microbial communities. The very fist time that I observed fluorescent bacteria through a microscope objective, I felt the need to share these images—however unremarkable they were—with friends, family, and online. As my project grew in complexity, so did the microbial communities, increasing the chances of capturing truly stunning images.

Like any scientific project, the early stages of my PhD involved extensive troubleshooting, often without immediate positive results. While setbacks in other projects might lead to frustration, I had the unique advantage of obtaining visually striking results—even if they were scientifically inconclusive. This helped me build resilience and maintain motivation, as every experiment yielded something tangible: either a figure for a paper or an image to share. For my mental health, I decided that both outcomes were equally valuable to me.

Many scientific image competitions actively seek submissions, and I was fortunate to have my work recognized. My first selection was for Figure1a [27], a scientific art exhibition in Lausanne, where my image *Eclipse in a Petri Dish* was displayed in 2021 (Figure 5.2A). This same image was later chosen for the March page of the Promega calendar. It depicts proline and tryptophan auxotrophic bacterial strains studied in this thesis, where imbalanced amino acid uptake creates alternating thick and thin sectors resembling sun rays. By adjusting the colour palette to resemble the sun and layering the image with circular overlays, I transformed the scientific visualization into a solar eclipse.

My image Microbial Earth (Figure 5.2B) was selected for the ISME outreach event flyer. It depicts cells growing within a round microfluidic chip. By using green and blue tones, I sought to evoke the image of Earth, subtly emphasizing the crucial role microbes play in our world. Using the auxotrophic strain microbial community again, I created *Growing Together* (Figure 5.2C), a time-lapse image that tells a story closer to scientific reality. It illustrates how auxotrophic interactions and amino acid exchange enable mutual growth. This image was displayed at ISME's Discover the Microverse event in August 2022 and later at the Alimentarium Museum in Vevey for the Microbiome Day in June 2023. Finally, *Microbial Ice* (Figure 5.2D) won the first prize at the NCCR image competition in 2023 and was exhibited for two months at the Shapes exhibition at EPFL. This image, featuring proline and isoleucine auxotrophic strains growing at low density, is distinguished by its intricate patterns.

Leveraging the visual appeal of microbial communities has provided an unexpected yet powerful way to connect with people—without them feeling intimidated by the complexity of the underlying science. A beautiful image can captivate anyone, regardless of whether they understand molecular microbiology. Indeed, the human eye is naturally drawn to spatial patterns, and this visual attraction becomes a bridge to scientific knowledge. When people grasp the scientific story behind the beauty, the impact is even greater. They not only admire the image but also experience the excitement of uncovering an invisible world—one that has existed alongside them all their lives.

Through my work, I aim to share these microbial landscapes not just for their aesthetic appeal but to tell the scientific stories they hold—to show that their beauty arises from biological interactions. My goal with these images and exhibitions is to enhance what the human eye perceives, adding a layer of scientific wonder. This deep fascination with science—especially the life sciences—is at the heart of my passion and what inspired me to become a scientist.

To quote Richard Feynman, Nobel Prize-winning physicist (1965): "*Scientific knowledge only adds to the excitement, the mystery, and the awe of a flower. It only adds—I don't understand how it subtracts*[1]."

While Feynman argued with an artist friend that his scientific understanding allowed him to see more beauty in a flower, I strive to share that knowledge—to make the full beauty of science accessible to all.

Communicating science with short presentations

Sometimes, images alone are not self-explanatory, and a public talk can be an excellent platform to convey a message. In the spring of 2016, I attended the first edition of *My Thesis in 180 Seconds* at UNIL as a spectator. Since then, it has become a tradition for me to attend every year. Finally, in 2022, I was a PhD student and had the opportunity to participate in the competition myself.

I had exactly three minutes to describe my PhD research to a general audience. You can watch my presentation (in French) online. This experience was truly unique—standing in front of more than 350 people, working within a strict time constraint, and using tools borrowed from theatre. I had to create analogies, inject creativity, and ensure that my explanation remained both accessible and scientifically

[1] https://www.youtube.com/watch?v=ZbFM3rn4ldo

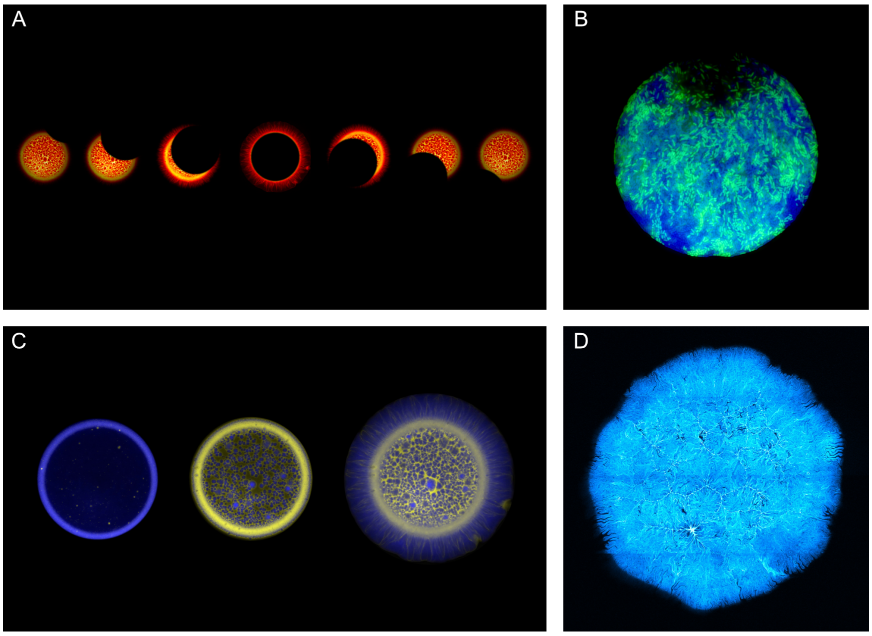

Figure 5.2: **Examples of my artwork based on microscopy pictures**. **A** "Eclipse in a petri dish", 2021. **B** "Microbial Earth", 2022. **C** "Growing together", 2021. **D** "Microbial Ice", 2023.

rigorous. It required to present my work in a way that would engage the audience without losing its core meaning.

Additionally, I gave a talk about my image featured in the *Figure1a* exhibition. I was invited to Martigny (Valais), where I shared my scientific and artistic process. Following the presentation, I had the opportunity to engage with the audience, answering specific questions about both the science and the artistic choices behind the image.

Both of these experiences were invaluable as a scientist. They provided an opportunity to reflect on my research and how to communicate it effectively. Moreover, the audience's questions were insightful, offering fresh perspectives on how people outside academia interpret and understand scientific concepts. These interactions reinforced the importance of clear and engaging science communication—something I continuously strive to improve.

Offering hands-on microbiology discovery through workshops

Microbiology is more than just scientific results or images of microbial communities—it's a vast and ever-present field. From the distinct flavours of cheese shaped by microbial composition [28] to its role in human health, immunity, and bioremediation [2], microbes influence our daily lives in ways that can captivate the general public.

As an experimental science, microbiology is best understood through hands-on experience. Engaging people in interactive activities—where they can manipulate bacteria and observe their behavior—makes the subject more accessible. During my Ph.D., I organized workshops to introduce diverse audiences to the fascinating world of microbial communities.

I have created and led interactive workshops at several events, including the university's open doors

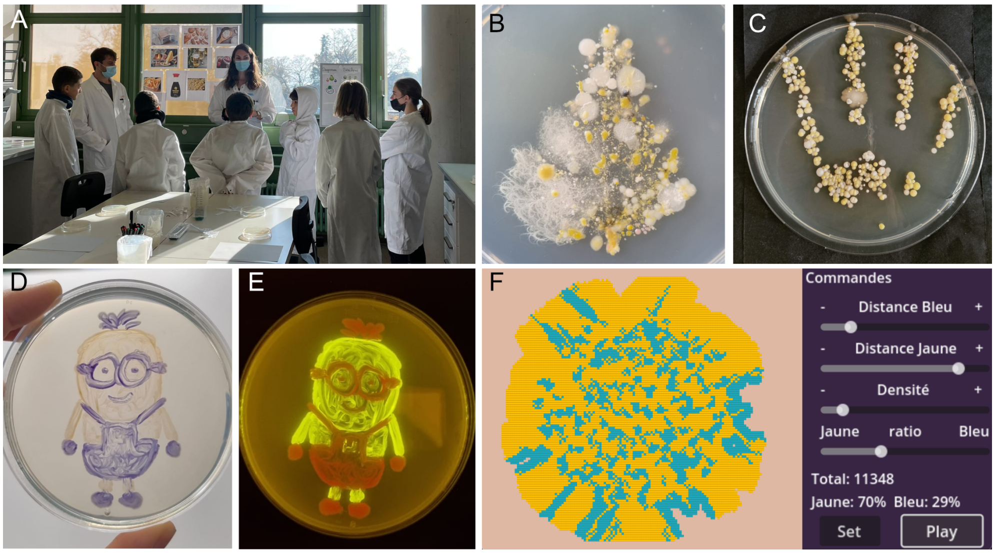

Figure 5.3: **Interactive activities carried out in my microbiology workshops**. **A** An introduction during a workshop that I organised at the JOM (2021). **B** Microbial handprint **C** Microbial leaf-print. **D** Drawing with fluorescent bacteria. **E** Drawing with fluorescent bacteria under blue light. **F** Screen shot of an interactive app showing how microbial communities grow and interact.

day (Les mystères de l'UNIL), where I engaged both school classes and the general public; the "Journée Oser Tous les Métiers" (JOM), a day where children of UNIL employees explore the university; visits to two high school classes; a week of visits in the Shape exhibition, and an art therapy workshop with the social services of the city of Lausanne for individuals receiving disability benefits.

With audiences ranging from 3 to 60 years old-from microbiology professors' children who already understand DNA replication to individuals who have never heard of bacteria—this diversity posed an exciting challenge. Year after year, I have refined my approach to better suit the participants. My workshops typically begin with a general introduction to microbes (Figure 5.3A), followed by showcasing Petri dishes with samples taken from different environments, such as a leaf (Figure 5.3B), a dog's mouth, a toilet, or tap water. I invited participants to place their hands on a Petri dish to discover their skin microbiota (Figure 5.3C). I also demonstrated how microbes used for positive purposes in everyday life, like baker's yeast, kombucha, and yoghurt, appear under the microscope. Using blue light, participants were able to observe fluorescent bacteria. When the setting allowed, I invited the audience to create colourful drawings on Petri dishes using my engineered bacteria (Figure 5.3 D,E). Additionally, I developed a small mobile app featuring a simple computational model of bacteria growing on an agar plate. I used Godot Engine [29], an open-source platform for designing video games. I implemented a grid-based simulation where each square represents a bacterial cell, with blue and yellow indicating two distinct bacterial species. The initial inoculum is positioned within a circular region at the centre of the grid, mimicking the experimental placement of a bacterial drop on agar. Users can modify the initial blue-to-yellow ratio and overall cell density using sliders. Cell division follows a simple set of rules: a cell can only divide (i.e., occupy a new square) if a neighbouring cell of the opposite colour is present. The size of the interaction neighbourhood can be adjusted via the "Distance to Partner" button. Upon division, the new cell is randomly placed within the available adjacent squares. With the sliders, the users can replicate the experiments that I have conducted in the lab, by changing parameters governing cell interactions (Figure 5.3F). It is available online [30]. This touch-screen interface offers an intuitive way to understand how bacteria grow and interact without relying heavily on technical jargon.

These workshops provide an excellent platform to convey key messages about how fascinating, important, and useful microorganisms are.

Shapes: Patterns in Art and Science

In the final months of my PhD, I was invited to showcase my art in an exhibition at the EPFL Pavilions Museum. This experience brought together and culminated all of my science communication efforts described earlier in this chapter.

The exhibition, titled "Shapes: Patterns in Art and Science," explored the richness of natural and artificial patterns that surround us. It brought together art, mathematics, materials science, and biology, highlighting the shared fascination of scientists and artists with geometric, dynamic, and symmetrical structures. Attracting 2,179 visitors from January 17th to March 9th 2025, the exhibition featured works by contemporary artists inspired by mathematics, alongside the emblematic creations of Dutch artist M.C. Escher.

I had the unique opportunity to contribute to the creation of part of the exhibition as an artist. Working closely with technicians, curators, and event coordinators, we collaborated on how to present my images and effectively convey the science behind them. This collaborative process involved numerous meetings and site visits prior to the exhibition's opening, allowing us to ensure that the final display truly reflected our collective vision. In this process, I could offer insights from both artistic and scientific perspectives. This dual role led to enriching discussions with professionals who shared the common goal of effective science communication, allowing me to appreciate diverse viewpoints.

During the exhibition's opening night, I delivered an introduction to my section, explaining my research, art, and process for both, to a general audience. Additionally, I organized a week of workshops for children aged 8 and older, linking microbiology and the microbial communities displayed in the museum.

The exhibition lasted from January to March 2025 but is still available online as a virtual tour (at the bottom of the page [31]).

Conclusions and outlook

The science communication activities undertaken throughout my doctoral studies have provided invaluable opportunities to engage with diverse audiences. Through a range of events, including art exhibitions, interactive workshops, and competitions, I have facilitated the discovery of microbiology for nearly 150 participants, including both children and adults. These initiatives have enabled meaningful interactions, fostering curiosity and appreciation for the microbial world beyond the academic

Figure 5.4: **Shapes exhibition**. **A** Exhibition guide and flyer next to the real-size range expansions. **B** Microbial communities part at the exhibition **C** Workshop with children. **D** Microbial sampling displayed during the workshop.

sphere.

Importantly, the continuity of these efforts is ensured, as I have shared my knowledge with new PhD students which have taken over some of these activities. Additionally, the collection of fluorescent microbial strains used for artistic petri dish illustrations has been shared with colleagues at UNIL and CHUV, where it will continue to support practical classes and workshops. This ensures that the resources and knowledge generated during my engagement in science communication will remain valuable beyond my direct involvement.

I strongly encourage other PhD students to participate in science communication, not only as a means of connecting with the public but also for the acquisition of essential soft skills. Engaging with audiences outside academia serves as a reminder that the broader public often perceives science through a different lens. Bridging this gap enhances our ability to communicate complex concepts effectively and fosters a more profound appreciation for the societal relevance of our work. The skills gained through these experiences—public speaking, adaptability, and outreach—will undoubtedly prove beneficial in my future. I am grateful for the opportunity to have developed these competencies in a supportive environment and will surely carry them forward into my professional journey.

References

1. Ahirwar, N. K., Singh, R., Chaurasia, S., Chandra, R., Prajapati, S. & Ramana, S. Effective Role of Beneficial Microbes in Achieving the Sustainable Agriculture and Eco-Friendly Environment Development Goals: A Review. *Frontiers in Environmental Microbiology* **5,** 111–123 (2020).
2. Maraz, K. M., Khan, R. A., Maraz, K. M. & Khan, R. A. An overview on impact and application of microorganisms on human health, medicine and environment. *GSC Biological and Pharmaceutical Sciences* **16,** 089–104 (2021).
3. Cho, I. & Blaser, M. J. The human microbiome: at the interface of health and disease. *Nature Reviews Genetics* **13,** 260–270 (2012).
4. Gupta, A., Gupta, R. & Singh, R. L. in *Principles and Applications of Environmental Biotechnology for a Sustainable Future* (ed Singh, R. L.) 43–84 (Springer, Singapore, 2017).
5. Matta, G. Science communication as a preventative tool in the COVID19 pandemic. *Humanities and Social Sciences Communications* **7,** 1–14 (2020).
6. Goldstein, C. M., Murray, E. J., Beard, J., Schnoes, A. M. & Wang, M. L. Science Communication in the Age of Misinformation. *Annals of Behavioral Medicine* **54,** 985–990 (2020).
7. Wirz, C. D., Cate, A., Brauer, M., Brossard, D., DiPrete Brown, L., Chen, K., Ho, P., Luter, D. G., Madden, H., Schoenborn, S., Shaw, B., Sprinkel, C., Stanley, D. & Sumi, G. Science communication during COVID-19: when theory meets practice and best practices meet reality. *Journal of Science Communication* **21,** N01 (2022).
8. Carvalho, G. S. & Lima, N. in *Importance of Microbiology Teaching and Microbial Resource Management for Sustainable Futures* 31–45 (Elsevier, 2022).
9. Lane, S., MacDonald, N. E., Marti, M. & Dumolard, L. Vaccine hesitancy around the globe: Analysis of three years of WHO/UNICEF Joint Reporting Form data-2015–2017. *Vaccine* **36,** 3861–3867 (2018).
10. Trabajo, T. M., Dorcey, E. & van der Meer, J. R. Bacttle: a microbiology educational board game for lay public and schools. *Journal of Microbiology & Biology Education* **25,** e00097–24 (2024).
11. Ghelfenstein-Ferreira, T., Beaumont, A.-L., Dellière, S., Peiffer-Smadja, N., Pineros, N., Carbonnelle, E., Greub, G., Abbara, S., Luong Nguyen, L. B. & Lescat, M. An Educational Game Evening for Medical Residents: A Proof of Concept to Evaluate the Impact on Learning of the Use of Games. *Journal of Microbiology & Biology Education* **22,** 10.1128/jmbe.00119–21 (2021).
12. *NCCR Microbiome the video game - https://nccr-microbiomes.ch/outreach/microbiomes-the-video-game/*
13. Lacey, M., Capper-Parkin, K., Schwartz-Narbonne, R., Hargreaves, K., Higham, C., Duckett, C., Forbes, S. & Rawlinson, K. University Student-led Public Engagement Event: Increasing Audience Diversity and Impact in a Non-Science Space. *Access Microbiology* (2023).
14. Duckett, C. J., Hargreaves, K. E., Rawson, K. M., Allen, K. E., Forbes, S., Rawlinson, K. E., Shaw, H. & Lacey, M. Nights at the museum: integrated arts and microbiology public engagement events enhance understanding of science whilst increasing community diversity and inclusion. *Access Microbiology* **3,** 000231 (2021).

15. *ARTIS-Micropia - https://www.artis.nl/en/artis-micropia*

16. *Musée de la main UNIL-CHUV - https://www.museedelamain.ch/fr/101/Expositions*

17. Gardner, J., Perry, C. & Cervantes, J. Igniting children's enthusiasm for microbes with an origami paper microscope. *Journal of Microbiology & Biology Education* **25,** e00151–23 (2023).

18. Scalas, D., Roana, J., Mandras, N., Cuccu, S., Banche, G., Marra, E. S., Collino, N., Piersigilli, G., Allizond, V., Tullio, V. & Cuffini, A. M. The Microbiological@mind project: a public engagement initiative of Turin University bringing microbiology and health education into primary schools. *International Journal of Antimicrobial Agents* **50,** 588–592 (2017).

19. Timmis, K. A Road to Microbiology Literacy (and More): an Opportunity for a Paradigm Change in Teaching. *Journal of Microbiology & Biology Education* **24** (ed Shaffer, J.) e00019–23 (2023).

20. Trudel, L., Deveau, H., Gagné-Thivierge, C. & Charette, S. J. The Course "Microbes and You": A Concrete Example that Addresses the Urgent Need for Microbiology Literacy in Society. *Journal of Microbiology & Biology Education* **21,** 50 (2020).

21. Clark, G., Russell, J., Enyeart, P., Gracia, B., Wessel, A., Jarmoskaite, I., Polioudakis, D., Stuart, Y., Gonzalez, T., MacKrell, A., Rodenbusch, S., Stovall, G. M., Beckham, J. T., Montgomery, M., Tasneem, T., Jones, J., Simmons, S. & Roux, S. Science Educational Outreach Programs That Benefit Students and Scientists. *PLOS Biology* **14,** e1002368 (2016).

22. De Lorenzo, V. Penitentiaries: Bringing microbiological literacy to the fringes of society. *Microbial Biotechnology* **17,** e70052 (2024).

23. Lebeer, S., Ahannach, S., Gehrmann, T., Wittouck, S., Eilers, T., Oerlemans, E., Condori, S., Dillen, J., Spacova, I., Vander Donck, L., Masquillier, C., Allonsius, C. N., Bron, P. A., Van Beeck, W., De Backer, C., Donders, G. & Verhoeven, V. A citizen-science-enabled catalogue of the vaginal microbiome and associated factors. *Nature Microbiology* **8,** 2183–2195 (2023).

24. The Isala project's empowered new insights into the vaginal microbiome and women's health. *Nature Microbiology* **8,** 1946–1947 (2023).

25. Clark, C. S., Ohstrom, A., Rolon, M. L., Smith, M., Wolfe, B. E., Wee, J. & Van Buiten, C. B. Sourdough starter culture microbiomes influence physical and chemical properties of wheat bread. *Journal of Food Science* **89,** 1414–1427 (2024).

26. Adkins, S. J., Rock, R. K. & Morris, J. J. Interdisciplinary STEM education reform: dishing out art in a microbiology laboratory. *FEMS Microbiology Letters* **365** (2018).

27. *[Figure 1A] - https://figure1a.org*

28. Melkonian, C., Zorrilla, F., Kjærbølling, I., Blasche, S., Machado, D., Junge, M., Sørensen, K. I., Andersen, L. T., Patil, K. R. & Zeidan, A. A. Microbial interactions shape cheese flavour formation. *Nature Communications* **14,** 8348 (2023).

29. *Godot Engine - https://godotengine.org/*

30. *Microbial community mini game - Estelle - https://eshtel.github.io/microbialcommunity/*

31. *EPFL Pavillions, Shapes - https://epfl-pavilions.ch/en/exhibitions/shapes*