Using Microbe Art to Engage with Science

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One December day while sitting at my computer, I came across an image that stopped me in my tracks: in front of me was a picture of a Christmas tree. This wasn't your average festive fir, though – it was drawn using multicolored bacteria strains: green evergreen boughs, red garland, a yellow star topper, and a dark trunk. I thought it was the perfect marriage of science and art, a living and vibrant experiment.

As a graduate student using the model organism *Saccharomyces cerevisiae* in my research, which is better known as the yeast used in bread and beer, I immediately wanted to figure out how I could turn my favorite microbe into a colorful painting. One problem: bacteria can be different colors – they can be red, purple, yellow, or green (and many shades in between) depending on the strain and the

environment they grow in. However, yeast are typically white, but can also be a reddish pink if there's a change in a certain part of their DNA, and will view any introduced pigment, such as food coloring, as a non-native chemical and basically spit it out. How could I emulate the pigment range of bacterial strains? Such began my experimentation with microbe art, where yeast are used as paint, left to grow for a few days, and yield a living piece.

I have always been interested in science and art. My grandmother gave me summer painting lessons when I was growing up and I've played the flute since fourth grade. I helped my dad revive newborn puppies born via C-section at his veterinary practice in high school and spent hours exploring outside and searching for insects and amphibians with my brother growing up. I have used artistic pursuits as a stress reliever from difficult academic classes since high school, and yeast art is no different. However, this particular project allows me to combine science and art and express myself in a truly unique way. It's a way I can present more of myself as a person instead of just as a scientist. Some of my friends have even introduced me with this identifier: "This is Liz, she makes yeast art."

Scientists are often portrayed as non-creative individuals, but the opposite is true. It takes creativity and imagination to develop experiments and think outside the box to solve complex problems. Many scientists are also involved in the arts, such as the author and natural scientist Beatrix Potter.

The acronym STEM (science, technology, engineering, and mathematics) has been well known for almost two decades and STEAM is a newer, expanded iteration incorporating the Arts. The term "STEM" was coined by Dr. Judith Ramaley while she was assistant director of the Education and Human Resources Directorate at the National Science Foundation (NSF) in the early 2000s[1] (#_ftn1).

A focus on STEM came out of American students continually being in the middle of the pack when it comes to science and math education performance; STEM programs aim to improve education in these areas, improve the equity of opportunities available in STEM subjects, and to make all students feel that they can succeed and that STEM subjects are not unattainable silos. The idea to include the Arts and expand STEM into STEAM came out of the "Ready to Innovate" study, the Americans for the Arts 2007 Nation Policy Roundtable, and others – the creativity offered by artistic pursuits can be beneficial to innovation, which in turn helps U.S. competitiveness[2] (#_ftn2), and makes more empathetic students. STEM/STEAM education soars when it allows students to explore their creativity and create a personal connection to a subject through their own unique way, which leads us back to yeast art.

I am far from the first to make microbial drawings. Alexander Flemming, who discovered penicillin, relied on different pigments in microbial strains to make his own agar art[3] (#_ftn3) [side note: agar is the medium in the petri dishes where microbes grow. Think of it as unflavored jello with lots of nutrients]. He was excited by the discovery of new bacteria that offered colors not yet a part of his pallet. This curiosity for the undiscovered and rare also helped him find penicillin and change the world forever. The Boeke lab (http://www.yeastart.org/) at NYU has genetically engineered yeast strains to contain individual pigment genes, resulting in a crayon box full of yeast color options that are used to print yeast art using a programmed robot; however, while this approach is exciting, these strains are not publicly available and therefor this library of colors is not an option for the casual yeast artist. There's an annual agar art competition put on by the American Society for Microbiology that started in 2015[4] (#_ftn4). Using microbes as "paint" and petri dish "canvases" to learn about how these organisms grow in different environments approaches science from a unique perspective. While creating beautiful results, it's also a powerful tool for teaching the scientific method where students test hypotheses until their desired artistic results are achieved, a true integrative STEAM

approach.

So what happened with my attempts at yeast art? I went through some failed iterations, but eventually developed a method where I could draw the outline of an image with yeast cells on agar using a wooden stick, let them grow for a few days until they were robustly visible on the plate, carefully place diluted food coloring inside the drawing area to make it vibrant, and immediately take a picture before the food coloring diffused through the agar. I made my creations during downtime while waiting for experiments to finish; they were a good outlet to relieve some of the stress from the repeated scientific failures and long hours of grad school and also a fun new challenge to tackle.

As a Science & Technology Policy Fellow, I no longer work in a lab, so don't have easy access to the yeast and agar plates I used to use for my artistic creations. However, I have recently learned how to make these living microbe experiments at home, using commercially available Baker's yeast and agar plates purchased online. I (and many others around the world) have been turning to art and music during the current pandemic as a means to self soothe, relieve stress, and feel an emotional connection to others. Returning to this creative outlet can once again serve as stress relief during these unprecedented times and bring science to a wider audience.

While microbe art is quite visually striking, the pieces I've previously done have more value as conversation starters and getting people interested in science. Friends I don't normally talk science with have engaged in discussion over these colorful plates. They're a fun way to learn about the properties of yeast and foray into a discussion about the importance of these microbe model organisms in research. Yeast are not just used to make bread and beer (as one person asked me) - they've been an important model organism in scientific research for decades and contributed to major breakthroughs. There has been an increase in the overlap of scientific and artistic pursuits over the last decade and I hope this continues. It makes science more accessible, opens up more avenues to engage with diverse audiences on a topic, and encourages collaboration between individuals with different backgrounds.

Image: Elizabeth Hoffman

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[1] (#_ftnref1) https://www.post-gazette.com/news/education/2009/02/10/STEM-education-is-branching-out/stories/200902100165#:~:text=Dr.,has%20spread%20far%20beyond%20NSF.

[2] (#_ftnref2) http://www.uastem.com/wp-content/uploads/2012/08/The-Prospect-of-an-A-in-STEM-Education.pdf

[3] (#_ftnref3) https://asm.org/ASM/media/Events-PDFs/Agar%20Art/History-of-Microbial-Art-optimized.pdf

[4] (#_ftnref4) https://asm.org/Events/ASM-Agar-Art-Contest/Home

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