Visually Exploring Fungi Through a Pattern-Based Lens

CSU Senior Honors Thesis

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This reflection paper is written for you, my fungal friends. I don't remember our first meeting, thanks to my father's ambition to find nourishment in the forest. Through our mutually nurturing relationship, parts of you have become parts of me. You have given me the gift of a unique perspective and in reciprocity to you, I teach what I learn.

From when I began classes at this university, I saw that most folks don't consider your existence. Even when they are trying to understand ecosystems in which you play a massive role. I am just one little person, but I chose to do what I could, and others encouraged me with their excitement. From one gathering to the next, a group of people discussed ideas and brought their friends. Interested people were all around, they just needed to be invited. Maybe this project began then, with the mycology club.

It is too obvious in our culture; how few people consider your fungal realm. Obvious in the monotony of consumption, the widespread use of lecturing, the fear of what we cannot see, and most extremely, the lack of wonder. We live in a weird time, as weird as any. Seemingly, we live in the perfect time to learn a lot from you. So, I present my fellow humans with one intricate opportunity to pause, wonder, and connect.

In the beginning, this art project intended to explore the shapes of your fungal bodies through the medium of photography and videography. As part of the process, this intent transformed into a project about artistic and scientific storytelling. The purpose of this film is to invite anyone and everyone to peek into what your fungal realm contains. To glimpse a mycological world view that blurs the lines between science and art. By showcasing some of the mesmerizing patterns you display, people from a broad range of interests will slide into connection with the beauty of your being.

I want to convey a feeling of childish wonder. Luckily, the lack of consideration for your fungal realm provides a great opportunity to show people something amazing that they have never seen before. We are visual creatures and when we watch the story of organismal diversity that surrounds us, it is hard for us to forget what we have been shown. The use of visual pattern connects with our brains in ways that cannot be underestimated. In 1990, J. D. Reid conducted a study looking into the role of pictures in teaching biology, concluding that they serve an invaluable purpose in capturing attention and communicating form. For these reasons, I think that there is significant value in the images portrayed in my short film.

All the videos in this film were captured using a Sony Arii camera that lined up perfectly with the eye piece of a microscope. When I was starting out, I thought that I would need an adapter to connect my camera lenses to the microscope, but with luck and some careful adjustments, I was able to clearly see the field of view through the microscope lens. Many of the timelapses I recorded involved taking a picture every 5 to 15 minutes as your fungal body would reach and grow. To accomplish this, I borrowed and then purchased a cheap and handy device known as an intervalometer which plugs into my camera and tells it to take a picture at a set interval. To capture varying scales of growth, I used a compound light microscope, borrowed from a friend, at 40X magnification and a dissection microscope, loaned by CSU Biology, at 4X magnification.

It is possible and sometimes necessary to learn through trial and error, but it is far more enjoyable to learn from each other. With an opportunistic eye, I reached out to the only teaching mycologist in the area to see what I could do to learn more. Dr. Ami Wangaline teaches a short summer mycology course at and was willing to let me be a volunteer teaching assistant for 2024. She gave me petri dishes, taught me how to choose and make agar to feed mycelial cultures, and was an amazing resource for helping me trouble shoot challenges. Dr. Wangaline is a woman who has spent more hours traveling to your microscopic world, than anyone else I know. The perspectives she shares from those experiences make me even more enthralled with who you are.

In addition to speaking with Dr. Wangaline, I searched academic databases for scientific uses of timelapses through microscopes. There are many studies that use microscopic timelapse photography as a valuable tool for studying development of organisms, though none looked at fungal development specifically. In one long-term time-lapse study of development (Gritti et. al., 2016) multiple automated machines were used to adjust focus, temperature of the sample, and angle of light. It is fun to learn about how high-tech this process can get, especially for specific analysis; however, their methods did not inform my own.

When I began to delve into your microscopic realm, I found new ways to put myself in a place where you could present yourself to me. I learned that your microscopic cells are all around me, in every breath I take, puddle I walk through, and even in between the cells of the plants. In the air, you are usually in the stage of your life that acts as your transportation vehicle, the spore. To coax you out I cooked up a lovely recipe of potato starch, dextrose, and a gelatin made from seaweed called agar. I made sure that no one else was already eating this meal by heating it to a high temperature in an autoclave. Then once I removed the lid and held it out to the air, you would find me and be nourished to grow. I repeated a similar process with cut sections of plant stems, roots, and water samples. When I first started the mycology club, I used pizza as a food offering to help fungal focused humans find our gathering. In many ways we are similar creatures.

While many molds appear very similar to the human eye, under the lens of a microscope we can see how differently you build your bodies. In some ways, your differences in growth were a challenge for me to keep in my plane of focus. Over the course of a few days, which was my typical length of timelapse, your hyphal strands would change where they were growing, and often grow up or down and out of focus. To improve my predictions of your growth I tried to understand how each culture was growing. If in the presence of another culture, you would tend

to grow differently than when you were alone, often producing more robust hyphae and defensive, chemical, secretions.

Another technical challenge that I encountered was condensation of the top of the petri dishes. The images would get darker and blurrier as there were more water droplets to see through. The food I was growing your cultures on has a very high-water content, and I learned that even small changes in temperature will cause condensation on the lid. I still have not managed to fully remedy this problem, but I was able to decrease its effect by adding another type of intervalometer to my collection of gear. This intervalometer connects to the microscope so that the microscope and its light will only turn on when the camera is going to take a picture. This way that light from the microscope has less of a heating effect on the petri dish. Due to this all being set up in my closet, there are still temperature fluctuations that cause condensation, but they are much less of a problem than before.

Once I had a collection of a few thousand images, I talked with a local filmmaker about how to best combine them into a video format. Using the Adobe program, PremierePro, paid for by Rocky Mountain Student Media, it was relatively simple, so long as everything worked the way it was meant to. It's just a bit of time distortion, how hard could it be?

Many of the mushrooms who star as models in this film were presented to me as I meandered through the forest after summer rains. Some asked me to contort my body to capture their image. All the while, the mosquitos tested how badly I wanted a stable shot. I collected videos over the course of about 20 field expeditions from June to August of 2024. I lived in the forest in a very small shack and would regularly find mushrooms waiting for me as I went about other tasks. Using the same camera I used to photograph through the microscope, I recorded habitats, colors, mushroom gills, mycelium, and happy humans, cooking and learning. My goal was to collect as much diversity of visual pattern as I could. To improve the videos I was collecting, I researched a way to make my normal camera lens into a macro lens so that I could focus quite close to specific aspects of the mushrooms. This part is a similar distortion of scale as the microscope, so that a tiny bug crawling across a mushroom will fill the screen without me having to lug a microscope through the forest. The cheapest and simplest way to get up close shots was by adding a short tube as a spacer between my camera and the lens. By increasing the distance from the lenses to the camera sensor, the camera was able to focus on objects much closer to the lens. Given the laws of physics, this made the plane of focus much more thin and extremely difficult to hold steady without a tripod. I was able to steady myself well enough for most shots, however the mosquitos would occasionally get me to move.

Once I had collected all the footage, I sorted through it finding the best shots, sorting them into different folders and attempting to stabilize shaky videos. Then I arranged the video clips so that they tell a visual story in the most inviting way possible. I realized that people viewing this wordless film might get lost, scared, and disengage from the wonder I wanted to lead them to. So, I offered out a poetic hand. First, I brainstormed what messages I wanted to share by drawing out a mind map. Then I connected my ideas to what was being shown in the video and finally recorded my voiceover. I intended it to be casually human, sharing my questions and inspiration to invite the viewer to consider your fungal realm. Teaching what I have learned.

While I was exploring the forest with my camera over the summer, I attended the Telluride Mushroom Festival as I have for many years. This year there was a special guest attending from Australia and the concepts she spoke about were on the same track as the questions I had been pondering. I sat down next to her one evening at a film and we discussed her lifestyle and how she has centered her work around your fungal realm. She is a photographer, conservationist, and a good-natured, humble, being. She has written a handful of books, including one that has greatly informed my project. In Meetings with Remarkable Mushrooms Alison Pouliot discusses the balance of cultural knowledge and scientific knowledge. She focuses on how we can all come together to be inspired and protect what we are so rapidly losing. As a photographer she greatly emphasizes the importance of visuals.

Alison is not alone in this discussion. In a collaborative paper titled "Seeing the environment through the humanities: A new window on grand societal challenges." published in 2015, Hall, Forêt, Kueffer, Pouliot, and Wiedmer present the importance of interdisciplinary work. Scientific facts alone will not encourage people to make changes in their life, which is what we really need for conservation action right now. The findings of science could be radically amplified if they were to partner with emotional meaning. Especially in the context of the environment, us humans need deeper meaning, from wonder and love to spark us into protecting what we have.

I realized that this deep, emotional, connection that could drive individual action directly contradicts our current capital world. Science often fits nicely with capitalism, creating numbers that show how much money our environments are worth. It's easy for legislators, business owners and even individuals to ignore the facts presented by science when they are presented in figures and numbers. When shown in the unspeakable language of beautiful patterns, it might be harder for people to ignore what they are destroying.

It became clearer to me through my research, that by making this film I am teaching, so I chose to research more about the way that humans learn biology best. I found a wonderful paper by Lawson, A. E. (2001) that describes a cycle in which we learn. It begins with exploration and allowing our brains to find inspiration before we learn any terms or concepts. I think that a visually focused film is a great way for people to feel this sense of exploration without any pressure to remember or learn specifics. From this explorative foundation, students will want to learn terms and concepts so that they can communicate about what they are seeing. The final step of the cycle is applying the learned terms and concepts to further explore. The learning and application of terms and concepts is something that could be gained if people choose to watch my film multiple times, or something that they will pursue by finding additional sources.

I was lucky to find a previous example of an art exhibit curated to display the work of microbiologists in exploring the mind-gut connection. Bencard, A., and Whiteley, L. E. (2018) shared about their collaborative project that engaged the general public in a personally impacting way. The exhibit that they set up was aesthetically appealing, which invited people to engage with a scientific topic they normally wouldn't. They showed the viewers how science could connect with their innate curiosity about beauty. The event was considered a great success, and the authors encouraged more scientists to collaborate with artists.

Once I was confident that others agree, science and art are intertwined, I needed to learn why they were ever separated to begin with. A 2002 paper by Eisner, E. and Powell, K. explained the philosophical beginnings of the scientific pursuit of truth. People believed that to find the truth it needed to be stripped of all humanness. Early scientists were right to notice the ways that unintended human biases can influence research; however, curiosity, beauty, and cultural knowledge are significant aspects of why we study what we study and have been left out of the equation. Eisner and Powell highlighted the importance of viewing science as a process. One in which "artistic modes of thought" heavily influence the way that scientists approach problems, design studies, and experience their research.

The perspective of science as a process from Eisner and Powell is reflected in papers about scientific story telling. A.J. Rose in 2017 and K. Padian in 2018 discuss the way that science is currently communicated in a non-story like way, but it doesn't have to be. Rose postulates that, like the separation from art, separation from narrative is a way to make science more rigorous. Both authors mention that the omission of a story holds science back in how well we can use it to engage others and remember what we learn.

I know from experience that observing your beautiful fungal features sparks my curiosity, and these papers showed me that others are affected this way too. Therefore, not only will a film be a beautiful thing to watch for a few minutes, but it could have a farther reach into conservation and developing a scientific understanding. If people are shown even my small example of your fungal beauty, they are more likely to want to study and protect your biodiversity.

As you demonstrate so well, relationships and connections are a valuable tool for our persistence on this planet. When our human minds see your patterns and can't help but be intrigued, that is one of those connections. Beauty and aesthetics come naturally to us and therefore offer a relatable pathway into science. This is explored in a 2008 paper by Jakobson, B. and Wickman, P. which looks at the ways that aesthetic qualifiers in scientific language help to engage young students while creating their own experiments. They found that students who were asked to think about science in an aesthetic way were more likely to engage and come to conclusions. By using words that they commonly use to discuss and explore their everyday world, students were more confident and creative towards the scientific process. This finding supports my use of poetic language in the film. It can also broadly inform the way that science is taught to both children and adults.

When audiences view this film, they feel a sense of relaxation invoked by the music and slow pace of the images being shown. The images are simple and focus on only a few fungal organisms, so it is easy for them to understand what they are supposed to be seeing. Natural patterns often have this effect on human brains which is supported by a study (Capaldi et. al., 2017) looking at human's natural desire to feel connected with nature. By interviewing 1,390 participants they found trends in people with better well-being having been more exposed to natural beauty. Some people have negative preconceptions about your fungal presence and based on this study, introducing them in the context of how beautiful you are will likely have the best success in engaging them. I predict that audiences seeing this work will appreciate having a space where they do not need to take away any specific understanding. All they need to do is

relax and let their brain enjoy the patterns on the screen. I think that people will value the freedom to be inspired through having time to get in touch with how these natural patterns make them feel.

A unique aspect of this film is that all fungi are local and grow in the Colorado Rockies. I think that when people watch a film of colorful and wild looking organisms they have never seen before they don't expect that they live in the same environment as them. I think that this connection to place and being amazed by your fungal structures that they have possibly been in the presence of is unique to this film and audience.

Finally, I want to thank you for your participation in my honors thesis. Humans are not always respectful of your fungal presence, but I hope that you see my film as a thoughtful appreciation of your many forms. I have not encouraged viewers of my film to eat or otherwise consume anything that could be harmful to them. I imagine that many of these viewers will be more curious about who you are and may find their way to foraging your fruits in the forest.

This project has come together for me in so many unplanned ways. I love pursuing film because it has rich potential to explore new world views and ideas. As I have shaped this film I have been shaped by it as well. I am more trusting in taking my time to observe mushrooms in the forest even when the others are far ahead of me. I now know that there will be beautiful things to record in nearly any location. I have been shown how to hear the stories that the forest is telling us. I understand how lucky I am to walk in the forest and be invited into the sometimes-hidden world of you, my fungal friends.

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