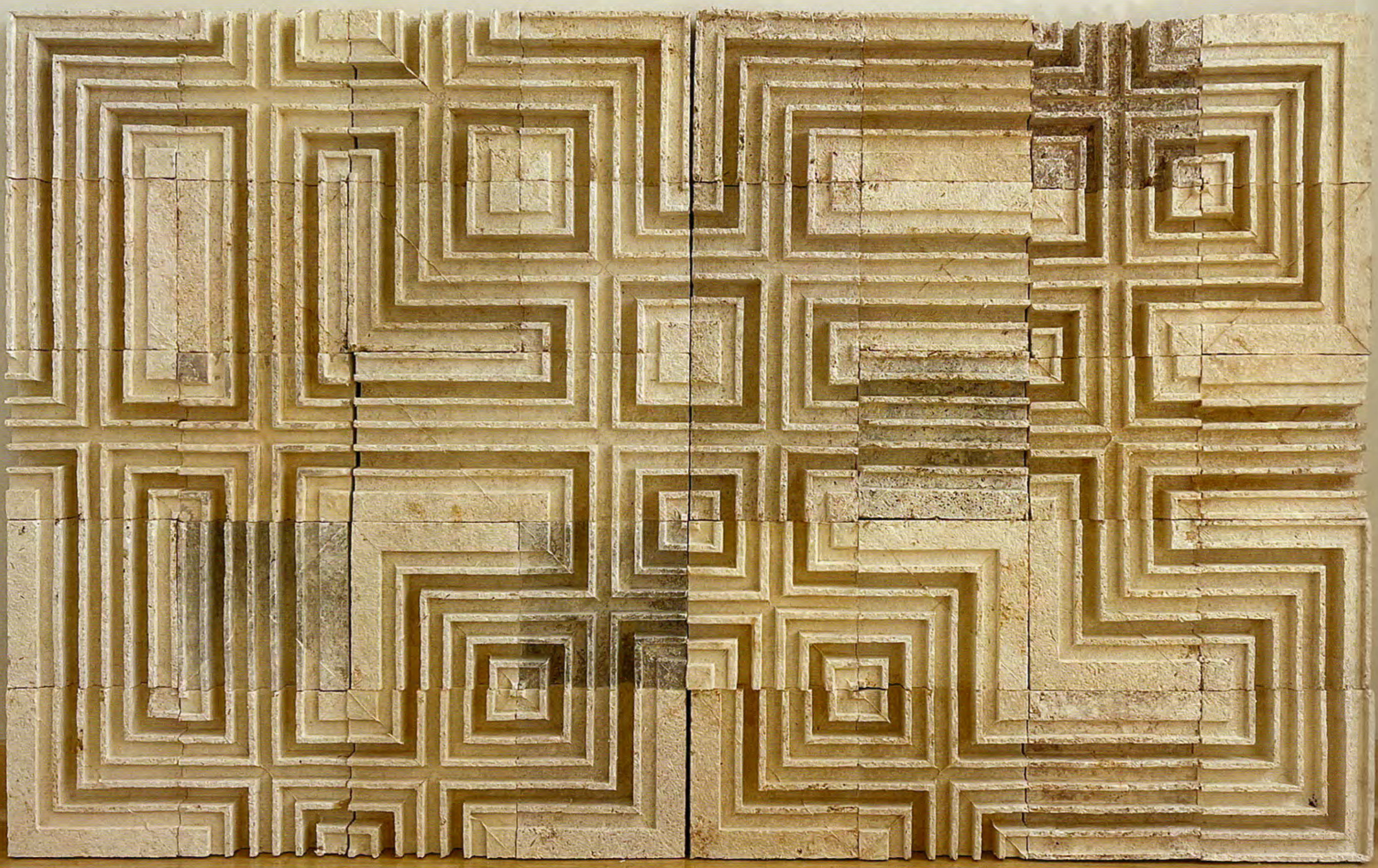
JONATHAN DESSI-OLIVE AND THOMAS SCHMIDT

This research is an exploration of the performative and functional possibilities of biohybrid materials that merge 3–D printed ceramics with mycelium composites. Initiated at the University of North Carolina (UNC), Charlotte, the project received support from an ArtXSci Collaborative Exploration Grant awarded in Spring 2023. The grant supported our independent research into "myco-ceramics" and an interdisciplinary course offered to students in art and architecture. Clay and earthen materials are abundant, natural, and widely utilized across art, architecture, and engineering. When fired into a ceramic state, clay offers properties such as hardness, dimensional stability, resistance to corrosion and wear, durability against weather, and insulative qualities.[1] These well-established attributes, combined with advanced digital fabrication and additive manufacturing technologies, make ceramics a versatile medium for a range of applications.

The goal of this project is to explore how ceramics can interface with emerging biomaterials like mycelium, aiming to replace fossil-based materials that dominate the arts and architecture. Although fossil-based foams, plastics, and resins are popular due to their versatility and cost-effectiveness, they are produced through energy-intensive processes that generate pollutants harmful to both the environment and human health. Despite progress in recycling, particularly in regions such as Germany and Singapore, the majority of these materials still end up in landfills, are incinerated, or undergo pyrolysis. To address these challenges, it is crucial to manage plastic consumption more sustainably and develop new low-energy, renewable materials that are designed for biological or chemical recycling.

Interest in mycelium composite materials (myco-materials) has grown among material researchers over the past decade because they are renewable, require little energy to produce, and can be composted. Myco-materials consist of agricultural by-products bound by a biopolymer derived from mycelium[1] – the root systems of fungi. Using processes similar to mushroom farming, mycelia are cultivated under controlled conditions until they form a living biomass. The basic methodology for working with myco-materials is akin to the casting arts. Loose cellulosic fibers inoculated with an appropriate fungus are packed into molds or formworks and cultivated under the right conditions for several days until the mycelium has fully bonded the fibers into a solid biomass. In most applications, the biomass is dehydrated, which halts growth and produces a lightweight, low-density material resembling styrene foam that can be broken down

FIGURE 1: **JONATHAN DESSI-OLIVE/MYCOMATTERS LAB** with Kristen James, Danielle Heckler, and Nathan King, *QRD Myco-Acoustic Array*, 2024. Mycelium-composite materials, 96" x 60" x 4". Photo credit: Jonathan Dessi-Olive



and composted.[2] Myco-materials are now an international enterprise, produced at a commercial scale as an alternative to plastics, foam, or styrene. Greater access to myco-materials for research and teaching has enabled artists, architects, and researchers across fields to cultivate large-scale pavilion structures, demonstrating fungi's potential in building applications.

The MycoMatters Lab at UNC Charlotte has been working with myco-materials to create regenerative art, design, and architecture across a range of scales, from product to pavilion. At the product scale, one of our longest-running projects involves designing and deploying quadratic residue diffuser (QRD) acoustic panels (**Figure 1**). Our panel designs can be combined and arranged to form expressive, functional arrays that enhance the acoustics of spaces intended for music and speech. We are scaling up production to create ceiling panels and larger arrays of wall panels with integrated mounting. Our interest in architectural acoustics has been evident in our work on large-scale pavilions, architectural prototypes, and sculptures. Our first large-scale pavilion, the *Monolito Micelio* (**Figure 2**), was cultivated from a single monolithic colony of mycelium at Georgia Tech in 2018, and was designed for a singing performance. The monolithic fabrication method[1] intentionally contrasted with the common practice of constructing mycelium structures from assembled bricks or blocks. In a more recent project, the MycoMatters Lab produced a sound-absorbing sculpture called *Phoenix* (**Figure 3**) in 2023. It was created using a technique called "hang dry," which facilitates the crafting of expressive 3-D curvatures in living sheets of myco-materials, aided by augmented reality technology.[5] These works, all made entirely of mycelium composite materials, illustrate that while myco-materials have numerous advantages, they can only address a limited set of material and performative criteria on their own. Therefore, we are now interested in

LEFT, FIGURE 3: **JONATHAN DESSI-OLIVE/MYCOMATTERS LAB** with Omid Oliyan and Rebecca Buntrock, *Phoenix*, 2023. Mycelium-composite materials, 240" x 240" x 96". Photo credit: Jonathan Dessi-Olive

BOTTOM, FIGURE 2: **JONATHAN DESSI-OLIVE/MYCOMATTERS LAB**, *Monolito Micelio*, 2018. Mycelium-composite materials, 96" x 96" x 108". Photo credit: Sean Miller

FIGURE 4. **ALIZA ANGUS**, *Modular Studies*, 2024. 3-D printed stoneware, glaze, and mycelium-composite materials, dimensions variable. Photo credit: Thomas Schmidt

hybridizing myco-materials with other natural and biomaterials, such as textiles and ceramics.

A key aspect of our project involved research through teaching. Our course, titled "Biohybrid Material Practices," was designed to bring together students from the art and architecture programs to experiment with cultivating materials from myco-materials and ceramics. Additionally, the course leveraged both programs' foundations in 3-D modeling and digital fabrication as a shared language. Through a series of short-term projects and hands-on experiments, students explored these biohybrid materials, culminating in a final team project. The outcomes ranged from functional designs and architectural elements to sculptural objects and other theoretical applications that showcased the integration of ceramics and mycelium.

The first project of the course challenged students to design a modular system that alternated between ceramic and mycelium bricks. Each student produced at least eight modules in each material, refining their designs through multiple iterations. This modular approach encouraged them to explore how these materials, with their distinct properties, could interact in architectural or sculptural contexts. Each module was designed to fit within a 36-cubic-inch bounding box, maintaining a manageable scale while fostering a dialogue between the organic and the fabricated. (**Figure** 4)

In our exploration of modular systems, the class investigated a broad range of design possibilities. We began by examining ceramic bricks as a fundamental modular system, considering how different stacking systems could affect both visual and structural outcomes. Students also explored connectors and adaptors within modular systems, drawing inspiration from examples like Lego blocks with their locking mechanisms and woodworking joints, which provide both structural and aesthetic connections. Some students also considered kinetic elements, such as ball joints, to introduce movement and flexibility into their designs.

As we progressed, students explored more complex approaches, including tessellating geometries that created intricate, repeating patterns and "nesting" forms, where one module fit seamlessly into the negative space of another. We also discussed incorporating negative spaces into stacking patterns to create porous screens that allowed light and air to pass through, expanding the functional and aesthetic possibilities of their designs. Students drew inspiration from architecture, design, installation art, and nature, using these references to push the boundaries of their work.

The project spanned six weeks, beginning with concept development and moving through formwork creation, mycelium cultivation, and clay printing. Early on, students produced physical prototypes of both ceramic and mycelium modules, which allowed for feedback and iterative design changes. In addition to their physical modules, students rendered large-scale theoretical assemblages of their systems, envisioning potential applications beyond the classroom (**Figure 5**). By the final critique, they presented both physical models and digital renderings, demonstrating their technical skills and ability to conceptualize innovative applications for biohybrid materials.

After completing the initial individual project, the course transitioned to a team project that paired one student from the art program with one from architecture. Using a collaborative learning approach, students and faculty shared insights from the first project to guide new explorations.[6] A central goal of this assignment was to move beyond creating separate modules and instead explore how mycelium could grow and bond directly with fired ceramics. Students were also encouraged to expand their projects by incorporating additional mediums or functions. The assignment began with discussions about various possibilities, such as integrating sound through speaker or acoustic panel designs, experimenting with light by creating custom fixtures, and using projection mapping technology to turn a wall relief into an interactive display. Students also considered different methods of presentation, including suspension, wall-mounting, or attaching their work to existing architectural elements.

The assignment allowed students the freedom to develop their own approaches, encouraging them to draw on their backgrounds and expertise to shape both the technical and conceptual frameworks of their projects. Notable projects included developing a biohybrid substrate for photo transfer techniques and laser engraving, creating terrazzo-like surfaces by hybridizing mycelium ceramic shards, and combining 3-D printed ceramic cylinders with mycelium to make a percussive musical instrument (**Figure 6**). The open-ended nature of the assignment encouraged students to think beyond traditional applications, resulting in a diverse array of final projects that showcased the creative potential of combining ceramics, mycelium, and other mediums.

"Biohybrid Material Practices" brought together students from art and architecture, fostering a collaborative learning environment where they could explore the intersection of digital fabrication, bio-materials, and design. By working closely together, students engaged in peer-to-peer learning, sharing skills and perspectives that enriched the creative process. Through hands-on experimentation and creative problem-solving, they developed a deeper understanding of how hybrid materials can be applied in innovative ways, culminating in projects that ranged from practical to experimental. This collaborative approach not only expanded their skillsets but also encouraged them to think more broadly about the possibilities of integrating sustainable materials with technology into their future work.

Jonathan Dessi-Olive is a researcher, designer, and educator who joined the School of Architecture at the University of North Carolina at Charlotte as an assistant professor in 2022. Jonathan is also the Director of MycoMatters Lab, a design and research laboratory that develops applications of fungi-based materials in diverse contexts.

Thomas Schmidt earned his MFA at Alfred University in 2009 and currently serves as an Associate Professor of 3-D Interdisciplinary Studios at the University of North Carolina at Charlotte. In his studio practice, Schmidt explores the integration of digital fabrication with a range of media.

FIGURE 5: **AMIN BEHROOZI**, *Modular Studies*, 2024. Digital rendering of stoneware and mycelium-composite materials, dimensions variable. Photo credit: Amin Behroozi

FIGURE 6: **HEATHER CHAN and RUBA KARKOUR**, *Nature's Rhythm*, 2024. 3-D printed stoneware, glaze, mycelium-composite materials, latex, wood, and cork, 32" x 24" x 44". Photo credit: Ruba Karkour

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