Cultivating Matter.

circular strategies
symposium 6

is the future alive?

November 20–21, 2025
University of Applied Arts Vienna, Auditorium,
Vordere Zollamtsstraße 7, 1030 Vienna

circular strategies
Building Construction
IOA Institute of Architecture
di:'angewandte
Universität für angewandte Kunst Wien
University of Applied Arts Vienna

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Editors: Gruber, Petra and Breuil, Camille

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Printed with financial support from I oA, University of Applied Arts Vienna

Project Management "Edition Angewandte" on behalf of the University of Applied Arts Vienna: Roswitha Janowski-Fritsch, A-Vienna

Layout, cover design and typography: Atelier Dreibholz, A-Vienna

e-ISBN (PDF) 978-3-903525-17-7

https://buildingconstruction.at/

Cultivating Matter. Is the future alive?

International Circular Strategies Symposium 6

November 20-21 2025, Vienna Austria.
The Symposium takes place at the Auditorium of the University of Applied Arts Vienna Vordere Zollamtsstraße 7, 1030 Vienna Austria.

The sixth International Circular Strategies Symposium addresses the theme of cultivating matter and poses the question of aliveness of future architecture.

The global scale of destabilization of environments and rhythms calls for an urgent transformation of our strategies, also in architecture and building. Biology is the only other model we have to shape another future towards a more integrated world. The symposium "Cultivating Matter. Is the future alive?" serves as a platform for presenting and discussing approaches as well as case studies in architecture and design, that explore learnings from biology and the integration of organisms in materials and structures. Aliveness is based on processes that require stable patterns of flow of energy and matter, resilient and adaptable to changes. Cultivation is the design of an environment of existence, growth and stability for other living systems. Adopting aliveness in architecture implies long-term strategies of design and care, by developing new patterns of circularity and living together.

The event is organized by the Department of Building Construction, I oA, University of Applied Arts Vienna, Petra Gruber and Camille Breuil. Image Credit © Atelier Dreibholz.

Scientific Committee:

- Ebba Fransen-Waldhör (University of Applied Arts Vienna, Austria)
- Wolfgang Gindl (BOKU University Vienna, Austria)
- Petra Gruber (University of Applied Arts Vienna, Austria)
- Barbara Imhof (University of Innsbruck, Liqiufer Systems Group, Austria)
- Margarete Jahrmann (University of Applied Arts Vienna, Austria)
- Andreas Körner (University of Applied Arts Vienna, University of Innsbruck, Austria, University College London, UK)
- Helga Lichtenegger (BOKU University Vienna, Austria)
- Clemens Preisinger (University of Applied Arts Vienna, Austria)
- Layla van Ellen (University of Innsbruck, Austria)

Cooperation Partners:
BOKU University Vienna, University of Innsbruck

Contact: circularstrategies@uni-ak.ac.at

Thursday, November 20, 2025 I 09:00 - 18:00

Welcome Address: Ulrike Kuch, Rector of the University of Applied Arts Vienna.

Introduction: Petra Gruber, Institute of Architecture, University of Applied Arts Vienna

Keynote: “Renewing Nature: Enacting Biodesign to Restore Ecosystems” by Carole Collet.

Sessions: Design with organisms, Bio-inspiration, Artistic approaches, Poster and Protoype presentations in the main Atrium.

Friday, November 21, 2025 I 09:30 - 19:00

Keynote: “Design Against Extinction” by Mitchell Joachim.

Sessions: Prototyping/ Fabrication, Bioreceptivity, Critical reflection.

Closing words: Camille Breuil, Institute of Architecture, University of Applied Arts Vienna

Conference Agenda

During the event, an exhibition of the ROOTARCH research project will be on display in the main atrium (ROOTARCH by Petra Gruber, Camille Breuil, Clemens Preisinger, Damjan Minovski, Andreas Körner, Rebekka Waters, Dominik Einfalt —funded by INTRA 2024).

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Abstracts proceedings

Circular Strategies 6

Cultivating Matter. Is the future alive?

Session 1: Design with organisms

Thursday, 20/Nov/2025:

11:15am - 12:15pm

Location: **Auditorium of the University of Applied Arts Vienna**
Vordere Zollamtsstraße 7, 1030 Vienna

11:15am - 11:27am

Extreme Matter: Mycelium Composites Across Material Regimes

Natalia Beata Piórecka*, Judith Ascher-Jenull*, Henning Dörfler*, Sophie Gruber**, and Barbara Imhof*

University of Innsbruck, Department of Experimental Architecture – Integrative Design | Extremes*, Arbeitsbereich für Materialtechnologie**

Abstract

The first strategy engages organic substrates such as hemp, sawdust, or straw, where mycelium grows through and partially decomposes the material, physically binding fibres into a dense, cohesive mass. This decay-driven fusion relies on enzymatic activity and mycelial entanglement to transform waste into structurally robust composites. The organic composite aims to achieve the lightest possible structure while remaining strong enough to withstand the racing environment, tested through its integration into a motorsport seat, where weight, impact resistance and performance are critical.

The second strategy explores the use of inorganic matter, such as sand or crushed mineral or synthetic waste, where mycelium functions not by decomposition but through encapsulation - locking inert particles within an organic matrix. This creates composites that suggest new models of containment, stabilisation, and reuse, particularly relevant in closed-loop systems. The heavier sand-based composite investigates the use of inorganic substrates for potential extraterrestrial applications, where structural stability and the use of in-situ resources are prioritised. These contrasting scenarios reflect how each material system is tailored to specific environmental and functional extremes, implementing various material-specific production strategies.

Both strategies use mycelium to create composites, but each applies a distinct logic tailored to its context. Together, the two approaches demonstrate mycelium's dual potential: as a metabolic processor for organic waste and as a structural entangler of inert matter. This redefines resilience as a biologically informed capacity to grow, adapt, and stabilise matter across extreme contexts.

Ultimately, this research aims to develop biohybrid composites that enable the reuse of inorganic construction waste, supporting future space architecture and more sustainable terrestrial building practices.

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Figure 1. Organic: Mycelium grown through fibrous agricultural waste. Credit: Natalia B. Piórecka

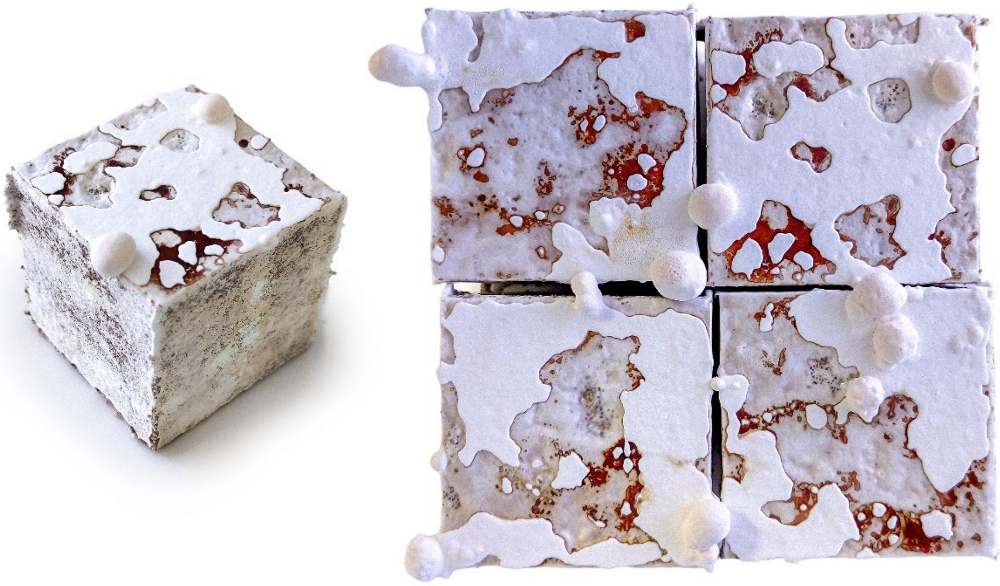

Figure 2. Inorganic Mycelium encapsulated sand-based substrate. Credit: Henning J. Dörfler

11:27am - 11:39am

MycoAir: Mycelium-based Air Filtration

Penn Ryan, Rashneet Chhabra, Keren Permutti

UCL, United Kingdom

Abstract

The London Underground is the world's oldest rapid transit system, but its deep tunnels host some of the most polluted air of any metro. Particulate matter (PM) levels can reach 46 times higher than the safety limits outlined by Transport for London (TfL). While TfL claims the air meets UK workplace exposure limits, independent studies have found PM levels hundreds of times above WHO-recommended limits (Saunders).

Research suggests that mycelium can serve as an effective air filter. A study demonstrated that mycelium absorbs NO_3^- and SO_4^{2-} better than granite, and its porosity allows for efficient PM accumulation. Importantly, the study found overall porosity more critical than surface microstructure for filtration (Lee).

MycoAir is a mycelium-based architectural system designed to purify air in the London Underground. It uses mycelium tiles to filter PM ranging from 1 to 10 μm. In tests, these tiles outperformed control materials commonly found in the Underground.

The tiles are designed to maximize surface area and PM capture. Our interdisciplinary approach included computational fluid dynamics to simulate air movement from incoming trains and how it moves PM over the tiles. A low-cost robotic fabrication method was developed for ease of production. We also devised a novel method to measure PM accumulation.

The final proposal is a modular wall and ceiling cladding system for underground platforms. The panels follow a circular life cycle: grown in molds, installed with simple tools, and rehydrated for regrowth after use. This process ensures that PM remains locked within the mycelium throughout its lifecycle.

MycoAir also promotes sustainability by using recycled paper pulp sourced from waste in the Underground as a growth substrate. This method reduces energy use, repurposes waste, and requires less maintenance than conventional HVAC systems, offering a low-cost, regenerative alternative to mechanical air filtration.

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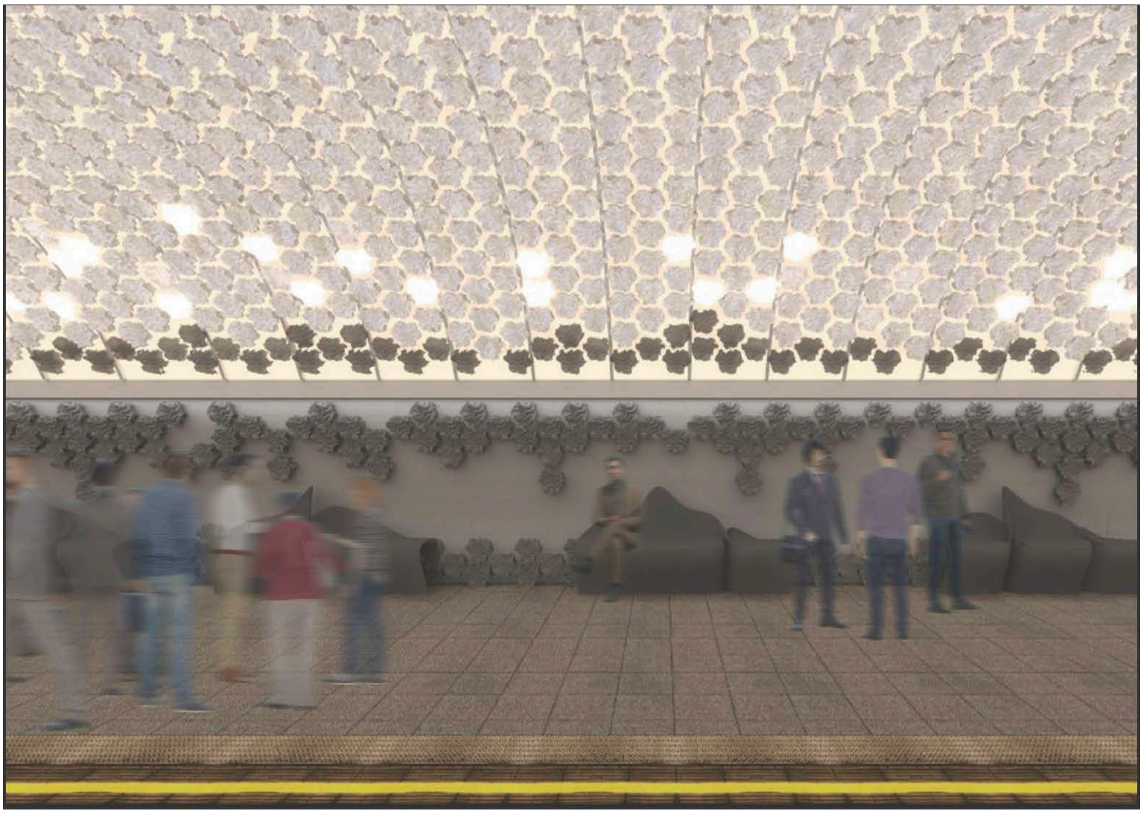
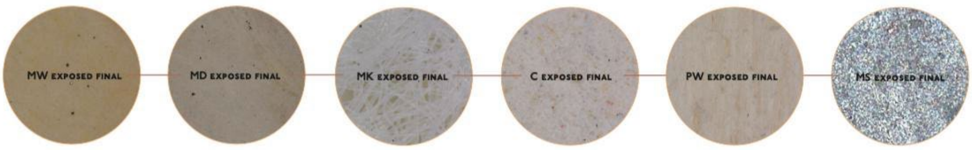


side_of_platform

RESULT SUMMARY OF CAPACITY OF MYCELIUM TO CAPTURE PARTICULATE MATTER



Total particle count:	3245	592	2133	317	425	0
Size range captured:	1-7 µm	1-9 µm	1-9 µm	1-7.5 µm	1-10 µm	0 µm
Most captured particle size and count:	2 µm, 1953	1 µm, 395	2 µm, 946	1 µm, 123	1 µm, 282	0 µm, 0

MW: Mycelium Wet

MD: Mycelium Dried

MS: Mild Steel

C: Ceramic

PW: Plywood

MK: Mask

SAMPLE'S ACCUMULATION CAPACITY:

1. WET MYCELIUM
2. FFP2 MASK
3. DRIED MYCELIUM
4. PLYWOOD
5. CERAMIC
6. MILD STEEL

table-mycoair

11:39am - 11:51am

Solidified elasticity of mycelium-textile hybrid architecture

Eliza Biala, Martin Ostermann

FuMaLab, Institute of Building Construction, Building Technology and Design IBK, University of Stuttgart, Stuttgart, Germany

Abstract

How can mycelium growth play an active role as the design driver in the development of an architectural project and biofabrication methodologies? How to adopt cultivation as the design medium?

Mycelium-based composites are a genre of materials which can be designed to target improvement in certain physical properties or fabrication methods. Textile hybridisation of mycelium-based composites has been thematised in multiple research studies as a method which can contribute to both goals - improving predominantly tensile properties and allowing for the new speculative fabrication processes.

The project develops a novel biofabrication method for cultivating doubly-curved geometries with elastic textile scaffolds and mycelium composites. The resulting mycelium-textile hybrid modules were to be applied for the spatial installation, Flight Into Shadow, in Salone Verde in Venice, in an appearance parallel to the Architecture Biennale 2025. This restrained the solution space into the geometries which could be cultivated easily in multiple copies within the available low-threshold infrastructure.

The paper discusses first how iterative investigation in the material composition, cultivation settings and maintenance, sterilisation concerns, and geometric limits shaped the design and biofabrication of the installation’s modules. The intermediate results and consequent feedback loops in the biofabrication process are thematised and reflected. The special focus is on the development of the elastic scaffold for cultivation allowing for cultivating both sides with the same expression of air mycelium surface and preventing cracking.

Secondly, the paper reflects on the mycofabrication process of 600+ copies of the selected module geometry. The heterogeneities of the resulting artefacts are reflected in the relation to the process parameters. Regardless, attempts to keep the established cultivation protocol constant, some unexpected growth phenomena (rhizomorphic mycelium growth on top of continuous tomentose mycelium surface and water blisters) occur. They give a base to further research or advancements in mycofabrication crafting.

The project proves that mycofabrication can be functionalised for the production of the scenographic elements for interior applications within a low-threshold setup. The anticipated aesthetic can be achieved in an interactive process when responsive experimental design and a learning-based approach are adopted.

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"Knitted Bio-Material Assembly." Presented at the ACADIA Conference, 2020

Flight_Into_Shadow__Fot_LaForgia_

Workshop_in_FuMaLab_Fot_Linus_Mayer

11:51am - 12:03pm

Bonding Mycelium Biomaterials with the Built Environment

Evgueni Filipov[1,2], Ben Bridgens[2], Jane Scott[2]

[1]University of Michigan,USA; [2]Newcastle University, UK

Abstract

In recent years, mycelium or fungi-based composite biomaterials have emerged as a genre of low-cost, low embodied carbon, sustainable, and potentially self-healing materials for use in packaging, consumer products, furniture, and more. In architecture, these biomaterials have been used to create acoustic panels, internal sidings, decorative features, and standalone structures. The mycelium has been shown to grow well with sawdust, hemp, straw, coffee grounds, and other plant-derived substrates, enabling composite materials that can fully biodegrade at end-of-life. However, the true nature of how mycelium bonds and integrates with other materials is unknownwhich limits our ability to use hybrid mycelium systems in large-scale building applications. In this work, we explore the morphology and underlying mechanics of how mycelium bonds with other materials. We study both solid materials such as woods, ceramics, metals and polymers, and flexible textiles of various organic and inorganic materials. We conduct experimental shear pull-out tests of coupons and fibers grown within the biomaterial. and explore the bonding interfaces with microscopic imaging. Our results show that mycelium can bond well with a variety of materials, and surprisingly the bonding with Copper, Zinc, Nickel, and their alloys are particularly strong. Furthermore, the contact surface area, texture, and porosity of the materials also play a role in the bond strength. The work offers guidelines for how to harness mycelium as a bonding agent for multi-material hybrid systems for various functional applications. Moreover, our work gives insights into how mycelium biomaterials can seamlessly integrate with existing and future architectural systems.

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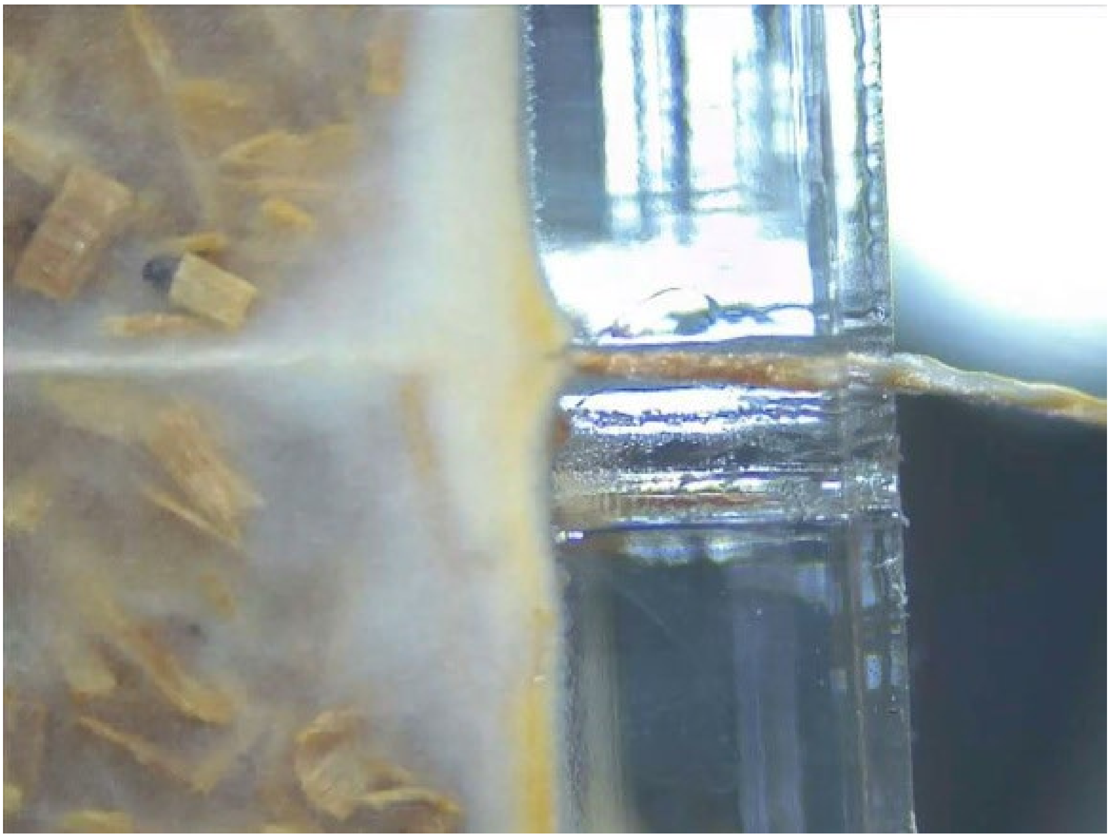
Fiber_emdedded_in_mycelium_Filipov_Evgueni_02


Growth_of_mycelium_adjacent_to_Brass_Filipov_Evgueni_02

Session 2: Bio-inspiration

Thursday, 20/Nov/2025:

1:30pm - 2:30pm

Location: **Auditorium of the University of Applied Arts Vienna**
Vordere Zollamtsstraße 7, 1030 Vienna

1:30pm - 1:42pm

From Plant Galls to Grown Devices: Toward Programmable Living Materials Inspired by Plant–Insect Interactions

Ille C. Gebeshuber

TU Wien, Austria

Abstract

Plant galls—specialized structures induced by insects, viruses, fungi or bacteria—demonstrate a remarkable natural capacity for interspecies co-design. Gall-inducing organisms, such as gall wasps, chemically and/or epigenetically activate specific developmental pathways in host plants, causing them to grow complex micro-architectures that serve as habitats, protective environments and nutrient sources for their offspring. These galls often feature sophisticated adaptive properties, including structures that could be interpreted as defences, bitter compounds that deter herbivores, precisely timed exit routes and—in rare cases—even ballistic dispersal mechanisms that launch them into the soil.

These structures embody biological principles highly relevant to the theme of cultivated matter: they are autonomously generated, functionally optimized and the result of inter-organismic communication and reprogramming. We propose to view plant galls as living analogues of programmable materials. The gall can be understood as a naturally bio-printed entity, where the instructions originate from one species and the form is produced by another.

We explore in our conceptional research the potential of this phenomenon as a model for future biointegrated materials and living architectures. Could humans one day direct plants to grow objects—structural components, tools or even devices—through targeted biochemical or genetic cues, much like insects direct plants to grow galls? The vision is not of extraction, but of symbiotic fabrication: architecture that grows, adapts and disassembles in harmony with ecological systems.

This biomimetic speculation contributes to emerging discussions on regenerative materials, self-assembling systems and the cultivation of responsive, embodied matter. By shifting from assembly to growth and from control to dialogue, we outline a pathway toward circular strategies that integrate care, maintenance and co-evolution. The gall becomes not just a structure, but a symbol: of interdependence, of resilience and of an architecture that is, in every sense, alive.

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1_oak_common_spangle

2_oak_silk_button

3_rose_spike_gall

1:42pm - 1:54pm

Butterfly Wing Scales as Inspiration for Multifunctional Architectural Surfaces

Florian Zischka[1], Matteo Corti[2], Cristian Manzoni[2], Harald W. Krenn[3], Ille C. Gebeshuber[1]

[1]TU Vienna, Austria; [2]CNR-IFN, Milano, Italy; [3]Department of Evolutionary Biology, Unit Integrative Zoology, University of Vienna, Austria

Abstract

Global temperatures rise and urban areas are increasingly exposed to extreme heat, pressing a dire need for sustainable and passive cooling strategies in architecture. Butterflies can inspire us in this matter, as they benefit from various multifunctional nanostructures on their wing scales. The properties enabled by these hierarchical structures range from structural coloring, hydrophobicity and self-cleaning properties to structural integrity and passive thermoregulation. Recent research indicates interesting thermal properties, especially a high emissivity within the atmospheric window (the wavelength spectrum from 7.5 µm - 13 µm, where the Earth's atmosphere is transparent for radiation). This work investigates different kinds of butterflies with a thermal camera as well as a novel hyperspectral imaging camera to identify species and wing areas of interest. The scale nanostructures are furthermore analyzed on micro- and nanometer length scales for potential application in the thermoregulation of buildings. With Scanning Electron Microscopy (SEM) and Focused Ion Beam (FIB) techniques it is managed to cut into single scales, to analyze the cross-section of these structures. Color scales, scent scales and reflective scales from various butterfly species (both tropical and native to the temperate zone of Middle Europe) are compared. The findings aim to highlight the potential of integrating biological nanostructures into human-made architecture for multifunctional designs.

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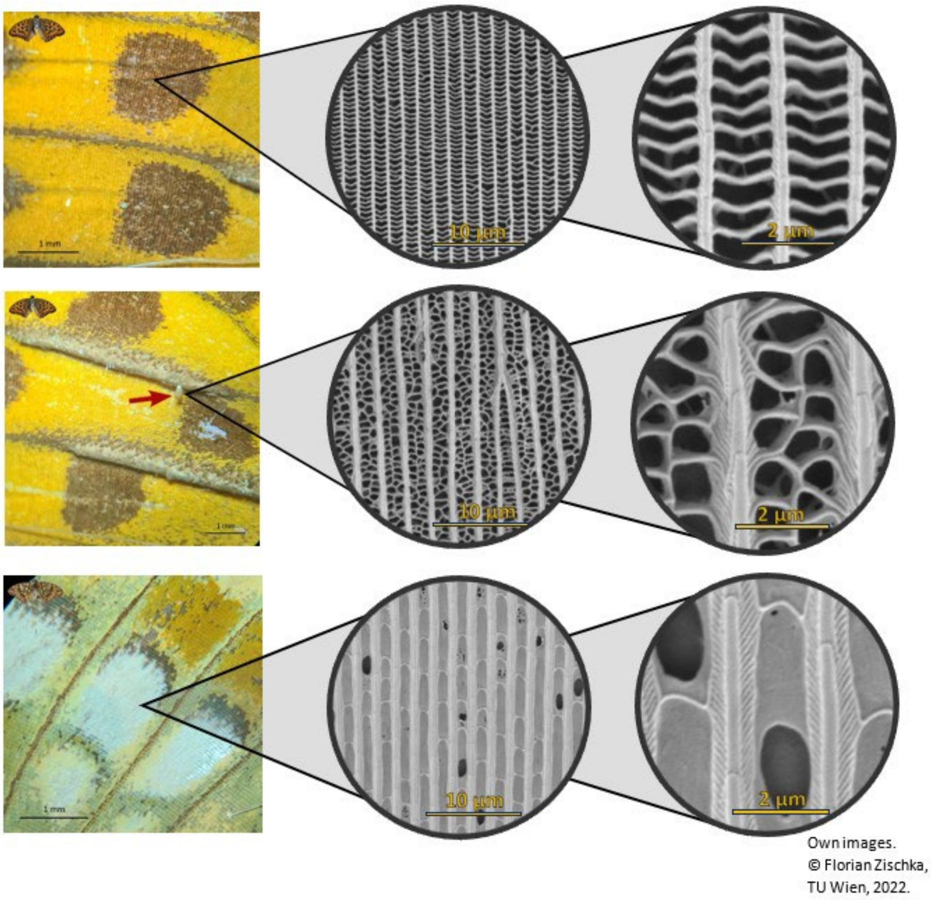

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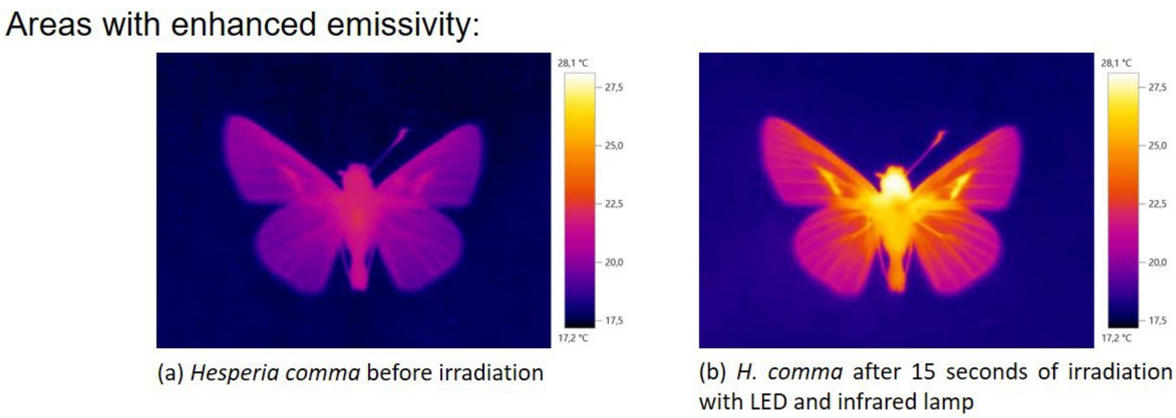

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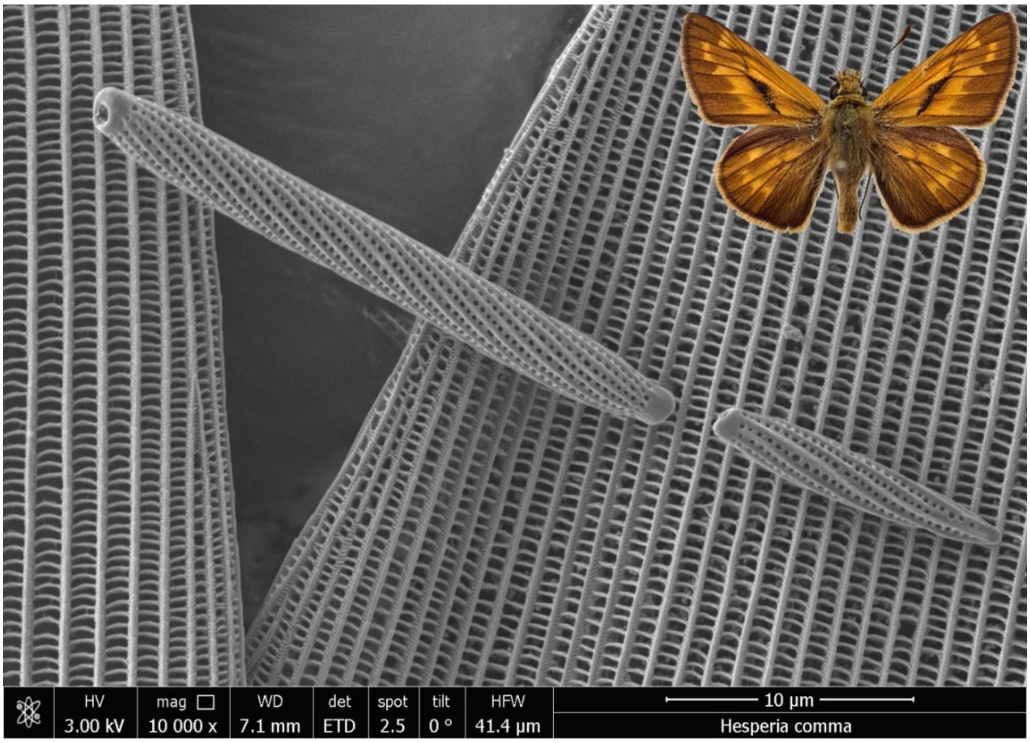

Hesperia_comma_orange_und_Duft_10k

1:54pm - 2:06pm

Entangled Mycelium – Textile Logic for Grown Architecture

Anne-Kathrin Kühner[1], Eliza Biala[2], Martin Ostermann[2]

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Abstract

Textile systems do not merely produce surfaces, they define spatial logic.
This research project investigates the architectural potential of combining textile construction techniques with mycelium-based composites (MBC) in the form of filament hybrids, producing upscaled, solidified textiles. Envisioning structural applications of textiles in adaptive, lightweight, and biodegradable architecture.

The central research questions are: Which textile construction techniques are suitable for building with MBC filaments? How can they be evaluated in the context of different architectural applications?

'MBC-filaments' are produced by stuffing textile sleeves with substrate inoculated with mycelium in the form of a paste. The process can be manual or semi-automated. The interoperability of the various parameters (sleeve material, the composition of MBC paste, filament diameter, and constructions (mesh-based with stretchability vs. surface-forming with dimensional stability)) is crucial for testing and comparing various textile techniques.

Construction choices are guided by manufacturing complexities, sizes, and shapes. Knitted meshes are stretchable and suited for round elements or non-load-bearing surfaces, but struggle with increasing weight and shape control. Weaving enables open or dense grids, offering lightness yet stable constructions and integration of diverse yarns. Macramé enables grids, foldable systems and can facilitate material combinations.

The research follows a practice-based approach, where artefacts are constructed and analysed. It builds on works by the authors from 2020-2025.

The work reflects on the production constraints of knitting, weaving and macrame MBC-demonstrators in the form of surfaces, shells and pillars. They are then evaluated under the four-criteria framework: (A) form stability and forming, (B) scalability, (C) integration of reinforcement materials and (D) biological growth behaviour, which are qualitatively reflected. Two main cultivation scenarios emerged during the works: hanging state (good for adjustments and contamination limiting) and bottom-up construction (preferable in up-scaled and structural scenarios). Macramé tests proved to offer potential not only for stable surfaces but also for integrating predefined breaking points to create foldable surfaces (held together by the intact sleeve material), which is relevant for adaptive components.
For particularly high structural stability, bio-welding at dense weaves or crossing points is essential. This project understands textile construction not merely as a technique, but as a design logic for grown architecture. This opens up a new perspective for the development of architectural systems that are embedded in the paradigm of 'cultivating matter', creating a post-extractionist built environment.

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Fig 1: MBCMacramee_Kühner_Anne-Kathrin

Fig 2: MBCTextileCollection_Biala_Eliza

2:06pm - 2:18pm

Nature-Inspired Construction and Reconstruction: Biomimetic Solutions for Resilient Building Assemblies

Ilaria Mazzoleni

Italy

Abstract

This research addresses the apparent conflict in building design between the need for stability and performance to withstand climate change and the imperative for degradability and circularity that leaves no waste. Drawing upon two decades of biomimetic design research, including frameworks from Architecture Follows Nature and site-specific investigations of the Nature, Art & Habitat Residency (NAHR), this paper defines the conceptual foundations and early hypotheses for a "coexistent" architecture. The central inquiry explores how architectural materials and assemblies can transition from inert, waste-generating objects to active participants in resilient, regenerative ecosystems, responding to a need for more conventional abstract structuring and contextualization in biodesign.

The methodology is grounded in the perspectives of geoecology and edaphology—fields that study the dynamic interaction between geological substrates, soils, and biological systems over time. This approach explores the potential for architecture to be designed with biomaterial responsiveness and slow transformation, allowing it to become geo-bio-reactive. This involves asking how principles of edaphology, especially the interaction between mineral substrate and plant life, can inspire new biomaterial assemblies strategies and structural morphologies.

The results suggest provocative possibilities for a paradigm shift: that buildings could be designed to mirror the adaptive, context-sensitive behaviors of natural organisms and geological formations, including their responses to periodic disturbances such as fire. This framework envisions life cycles that incorporate transformation, degradation, or decomposition as purposeful, ecologically valuable phases, thereby reducing long-term environmental impact and enhancing climate resilience.

In discussion, the research is framed as foundational thinking on how architecture can emulate the cyclical logic of natural systems—engaging dynamically with environmental forces, embracing disintegration, and ultimately contributing to the metabolic flows of the ecosystem. This aims to contribute to the field by defining the epistemological and practical implications of an architecture designed for resilience and regeneration in the face of climate change.

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pioneer_lives_mazzoleni_ilaria_01

in_between_life_evolves_mazzoleni_ilaria_02

Session 3: Artistic approaches

Thursday, 20/Nov/2025:

2:45pm - 3:45pm

Location: **Auditorium of the University of Applied Arts Vienna**
Vordere Zollamtsstraße 7, 1030 Vienna

2:45pm - 2:57pm

What role can textiles play in greening architecture?

Antonia Ablass

Abstract

Greening urban spaces is of growing importance in the face of climate and demographic change. While vertical greening is a promising and versatile solution in space-limited contexts, its application remains limited. Studies point to social, economic, and ecological challenges. This project explores vertical greening by using textiles as the direct medium for plant growth. Although this technique is expanding in the arts and fashion, it has been overlooked in architecture, urban design, and planting systems. This gap is addressed by developing a series of prototypes that enable plants to grow directly on textiles. Seeds are applied onto fabrics shaped into sculptures or installations, allowing plants to grow and root directly into the textile. The primary textile techniques used are weaving and knitting, with a focus on double-layered structures that can integrate automated water systems and scaffolds. The textile materials employed are of natural origin only, mainly including wool, linen, and cotton. While linen has strong water-absorbent properties, wool appears to have a longer life cycle. Using textiles as a growing medium offers several advantages over conventional vertical greening. Textiles are lightweight, adaptable, and naturally aesthetic. Additionally, they absorb and distribute water across the surface, keeping seeds moist. Using seeds has various advantages in comparison to greenhouse-pregrown plants. Furthermore the system allows adaptation to different ecological, social and architectural contexts. The use of natural textile materials is suited to create circular systems but this comes at the expense of a shorter lifecycle. Another disadvantage is a high demand for water. This project shows the potential of incorporating textiles into greening architecture. While the focus has been on small testing prototypes, these learnings should be applied to larger-scale production systems. Further research in this emerging field could explore holistic water systems, adaptations to different habitats, improved longevity and the use within regenerative cycle systems.

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Fig 1: greencone_ablass_antonia
Fig 2: olla_ablass_antonia

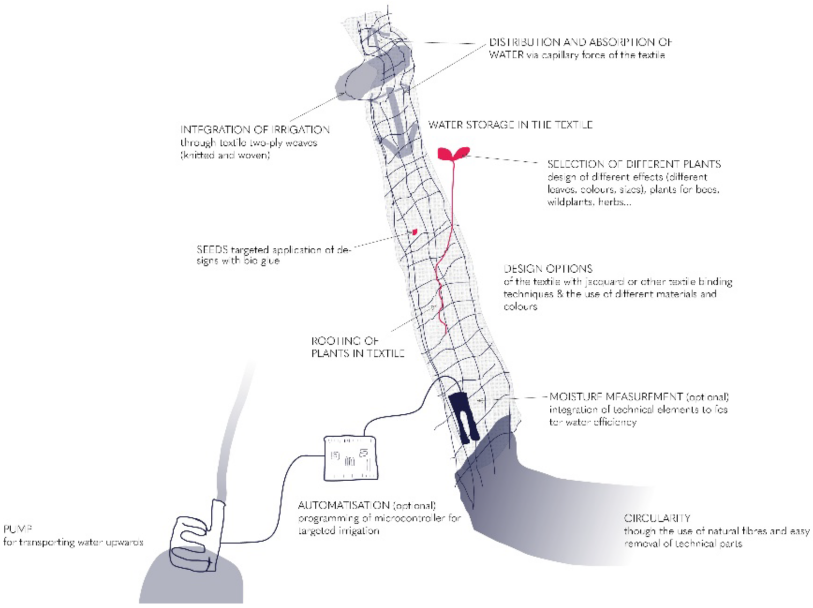

Fig 3: systemGrafik_ablass_antonia

2:57pm - 3:09pm

Postcards from the Future, Singapore 2125: From Garden City to City in Nature

Gabriel Kaprielian

California Polytechnic State University, United States of America

Abstract

Singapore is known as a "Garden City," a title that the city-state has embodied through an extensive network of urban trees, lush city parks, and more recently green facades and roofs. While it has earned a reputation as a world-wide leader in biophilic design, these green spaces have focused primarily on human benefits that rely on control of the natural environment often replacing the historical ecology that has been shrouded by layers of development. This is especially true of Singapore's shoreline, where the country has used land reclamation to expand its area by 25 percent. While the construction of new land was seen as a vital part of national building, it erased nearly all the original shoreline along with the mangrove forests, natural beaches, and indigenous villages. To complicate matters, Singapore is particularly vulnerable to sea-level rise and compound flooding as roughly a third of the land resides below 5-meters.

"Postcards from the Future" invites the public to explore the past, present, and potential future transformations of the country's shoreline through Augmented Reality (AR) installations at 24 designated locations that build place-based knowledge, serve as a platform for collaboration across disciplines, and an interactive tool for public engagement. The AR installations visualize sea-level rise scenarios and potential resilience strategies that include nature-based solutions, biomimetic engineering, and traditional ecological knowledge. Building off the country's Green Plan 2030 pillars "City in Nature" and "Resilient Future," the project seeks to reframe the challenges of sea-level rise as an opportunity to merge tidal ecosystems with adaptive architecture. By embracing the rising sea and natural processes of regeneration, static shorelines may be replaced by a continually changing shore area, where urban waterfronts are designed in collaboration with coastal habitats. The project was hosted by the Earth Observatory of Singapore. It brought together a transnational and interdisciplinary partnership between scientists, architects, engineers, and artists to provide a platform to exchange knowledge and enable discourse that speculates on how Singapore can develop a long-term planning framework that foregrounds biodiversity and natural systems with climate change resilience to envision a living city designed for all life.

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Image_Kaprielian_Gabriel_01

Image_Kaprielian_Gabriel_02

3:09pm - 3:21pm

βI⊙$^{-9}$ ∞ LUDIC^{9} Fermenting the Bio-Ludic: Toward a Living Architecture of Symbiotic Play

Ivan Jakaric, Margarete Jahrmann

Universität Angewandte, Austria

Abstract

βI⊙$^{-9}$ ∞ LUDIC^{9} explores symbiosis, care, and metamorphosis as principles for reimagining architecture and design through artistic research. It investigates how living matter—microbial cultures, biofilms, and cellulose skins—can become more than materials: companions in processes of play, transformation, and ecological responsiveness.

Methods combine microbial fermentation, material prototyping, and ludic experimentation. Bacterial cellulose and halophilic biofilms are cultivated into masks, membranes, super symbiotic food, and bio-tables that act as discourse-activating objects. In themselves, these ludic artefacts are not epistemic things, but through their participation in play—as method—they enter what has been called the "magic circle" of artistic research. Here, objects evolve into epistemic objects: they generate insight by moving from material growth to discourse, reflection, and peer exchange, producing knowledge through their unfolding metamorphosis.

Results show that these bio-ludic artefacts do not behave as fixed products but as evolving players in multispecies entanglements. Bio-tables foster spaces of care, where microbial growth becomes a sensory presence. Masks and membranes blur nourishment, protection, and performance, while halophilic films embed salt and water cycles into material practice. The outcomes reveal architecture as a living ecology, metabolised through time, smell, and decay, where design is cultivated rather than fabricated.

The findings suggest that play is not only a metaphor but a method for generating artistic-epistemic objects. By staging microbial life and human bodies in acts of care, uncertainty, and co-creation, βI⊙$^{-9}$ ∞ LUDIC^{9} produces knowledge that resists extractive and anthropocentric models of design. Architecture is reframed as a ludic and symbiotic practice: an interface of care, a site of metamorphosis, and an ecology of becoming.

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NeuroSmellPlay_jakaric_ivan_01

BioLudicTable_jakaric_ivan_02

3:21pm - 3:33pm

SlimeMoldCrypt

Stephanie Rentschler

Universität für angewandte Kunst Wien, Austria

Abstract

This project is questioning an alternative vision of digital security through an installation that employs the slime mold Physarum polycephalum as both inspiration and active participant. Unlike conventional encryption systems such as RSA or AES, which remain invisible processes managed by corporations, this work makes security tangible, fragile, and alive. Physarum is a single-celled organism without a brain, yet research has shown that it can solve mazes, optimize networks, and adapt dynamically to changing environments. Its unpredictable but patterned growth becomes a source of biological entropy, a living analogue to random number generation.

In the installation, the vitality of the organism determines the strength of encryption. If it is fed, moist and healthy the security factor of your data increases. When it weakens through neglect, protection declines. Users must therefore engage in ongoing acts of care: feeding, monitoring, and cultivating the organism. Encryption here is no longer an abstract algorithm hidden in a server farm, but a practice of daily carework. This dependency introduces new conceptual frames such as "cryptographic empathy" , the ability to read and respond to the organism's needs, and the willingness to align with biological rather than computational time.

By playfully coupling data protection with the rhythms of living matter, the installation reveals encryption as a relationship rather than a service. It raises an unsettling but productive question: what happens when the security of our most personal information depends not on corporate infrastructures or mathematical proofs, but on our own capacity to care for a vulnerable life form? In this speculative model, privacy is no longer outsourced. It becomes embodied, relational, and fragile.

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20250612studioStephanieTentschlerDesignInvestigations0009_Kopie


20250612studioStephanieTentschlerDesignInvestigations0068_Kopie

Session 4: Prototyping/ Fabrication

Friday, 21/Nov/2025:

11:15am - 12:15pm

Location: **Auditorium of the University of Applied Arts Vienna**
Vordere Zollamtsstraße 7, 1030 Vienna

11:15am - 11:27am

Unscripted Material: Vulcanized Fiber and the Aliveness of the Industrially Manufactured in Architectural Practice

Gonzalo Vaillo, Lukas Allner, Karolin Schmidbaur

University of Innsbruck, Austria

Abstract

Recent architectural discourse has increasingly turned toward the expanded distribution of agency, particularly privileging biological and digital entities. Within this framework, the notion of aliveness—and synonyms—is frequently restricted to living systems, thereby excluding human-manufactured materials from being considered active participants in architectural processes. Yet a larger anti-anthropocentric perspective invites a broader understanding: aliveness need not be the exclusive domain of living entities but may also emerge from the contingent behaviors of human-made materials themselves. Vulcanized fiber (VF)—a chemically bonded cellulose compound derived from textile and cotton waste, and thus a biomaterial—embodies this condition. Exhibiting unpredictable responses as it transitions from wet pliability to dry rigidity, VF resists complete instrumentalization. Its expressive transformations are shaped by manual and environmental interactions, rendering it an active material rather than passive matter.

This contribution presents a design research case study that explores the collaborative co-design and co-construction of a spatial structure using vulcanized fiber. Unlike conventional construction materials, VF cannot be fully predetermined: when transitioning from wet to dry, each piece undergoes unpredictable curling, warping, and dimensional shifts. Here, aliveness is conceptualized in the persistent divergence between the geometry intended in the preliminary design and the morphology that ultimately emerges through fabrication. To engage with this variability productively, the design and construction processes employ technological tools—3D scanning, computational combinatorics, and augmented reality holographic instructions—not to enforce control, but to register and adapt to these deviations. Construction tolerances, allowances, and flexible assembly protocols become essential, making each VF element a singular participant in the collective construction.By foregrounding the incapacity to predict exact form, the project emphasizes the agency of an industrially produced biomaterial and reframes its role in architectural practice. The aliveness of VF lies precisely in its resistance to replication and its demand for negotiation in both design and assembly. This challenges the conventional dichotomy between nature and manufacture, as well as the assumption that industrial products are inert and uniform. Instead, the project demonstrates that the industrially fabricated can also introduce contingency, difference, and co-performance—forms of aliveness—into the architectural processes.

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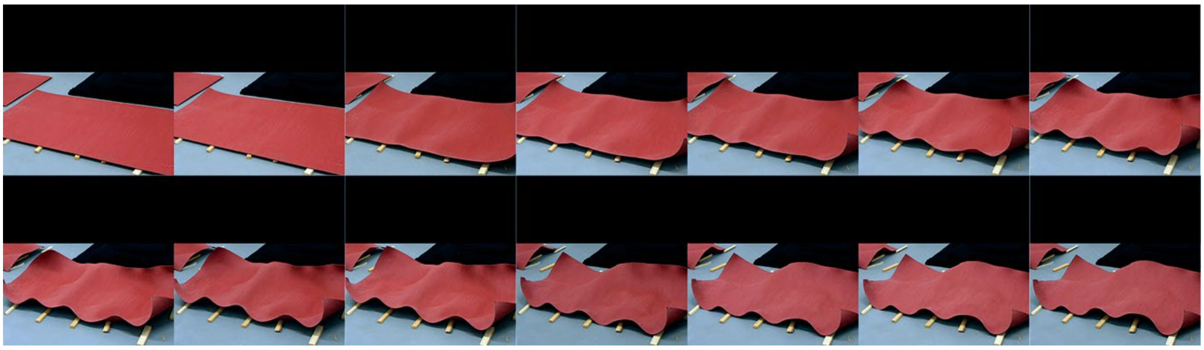

Figure_1

Figure_2

11:27am - 11:39am

Graded Biofoam Systems For Responsive Architectural Assemblies Through Robotic Casting

Lena Fritsch

Royal Danish Academy, CITA - Centre for Information Technology and Architecture

Abstract

Foams are ubiquitous across industries such as construction, aerospace, furniture, and packaging. Their appeal lies in a unique combination of properties: extremely low weight relative to volume, high thermal and acoustic insulation, and the capacity to absorb shocks and impacts. Beyond utility, foams also transformed the way bodies meet surfaces, introducing softness, cushioning, and responsiveness into everyday design.

Yet most foams in use today are petroleum-based, toxic, and chemically irreversible, making them non-recyclable waste at end of life. This research addresses that condition by developing a biodegradable and thermoreversible biofoam system based on gelatin, glycerin, and water. By combining these ingredients with foaming agents such as sodium bicarbonate, citric acid, or surfactants, a castable foam is produced whose stiffness and porosity can be tuned through recipe variation. Unlike polyurethane foams, the resulting material can be re-melted, re-cast, and reintegrated into new batches, closing the material loop. Failed components or off-cuts are returned to the system, establishing the foam as a reusable medium rather than a single-use product.

To translate this into a design prototype, the research introduces a robotic casting method where a UR5e arm tilts molds during the curing process, using gravity to guide the flow of differently graded mixtures. This enables continuous gradation between softer and firmer regions without multi-part assembly. The findings demonstrate three qualities: (i) the feasibility of thermoreversible biofoam fabrication, (ii) the successful integration of robotic casting as a method for embedding gradients, and (iii) the capacity to spatialize responsiveness within a single material system. This work builds on research into functionally graded and variable-property materials in architecture, which has emphasized the potential of spatially differentiated matter to replace discrete assemblies. Potential applications include adaptive insulation panels, responsive cushioning, and graded surface assemblies that tune softness or rigidity to performance requirements. The project culminates in a curvature-driven wall panel prototype, in which zones of softness and stiffness are distributed according to surface geometry. Current limitations concern scale, environmental durability, and long-term performance, which are identified as areas for future development.

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Fig 1: Biofoam_Fritsch_Lena

Fig 2: BiofoamCloseup_Fritsch_Lena

11:39am - 11:51am

Material Learnings: Embracing Biomaterial Agency in Architectural Education

Kilian Bauer

University of Innsbruck, Austria

Abstract

With biomaterial fabrication on the rise across architecture and design, it is essential to conceive, develop, disseminate and teach tailored design strategies that address the inherent properties of biomaterials. While robotic 3D printing offers a promising platform to support such a shift in architectural production, biomaterials remain challenging due to their volatility and performance limitations. In response, two approaches have emerged: one seeks to overcome these constraints through technological innovation, while the other embraces the constraints by developing fabrication-informed design strategies that address the material´s behaviour. The student work in Figure 1 focuses on the latter by exploring how material characteristics can guide innovative design processes in the framework of a *Design & Build* elective course, instructed by the author. The course brief challenged students to rethink design objects or architectural components within the confines of a predetermined material system: construction timber combined with a 3D-printable paste from wood derivatives. The biomaterial mixture used is both biodegradable and suitable for circular reuse, making it well-suited for rapid prototyping in an educational context as well as for future applications in sustainable architecture. The circular material life cycle (Figure 2) is adaptable to locally available resources, as the biomaterial only contains plant fibers and gelatine. Since the 3D printed paste hardens slowly through natural drying, its physical behaviour shapes the design process. Students applied this knowledge by slowly drying 3D-printed, flat panels on a curved formwork to produce curved shingles in an otherwise unprintable shape (Figure 1a). Others applied their understanding of the material´s non-uniform, yet heuristically predictable shrinkage behaviour to fabricate conical components for a pressure arch (Figure 1b). These examples demonstrate that in biomaterial fabrication, material constraints are not merely limitations – they actively shape the design process. Thereby, material agency shifts from a (emergent) design intention to a technical asset. Beyond the communication of technical knowledge and practical research experience, the teaching initiative also trains future generations of architects in material- and fabrication-oriented design thinking by fostering problem-solving skills for complex material systems in preparation for the challenges of a world of ecological disruption and resource scarcity.

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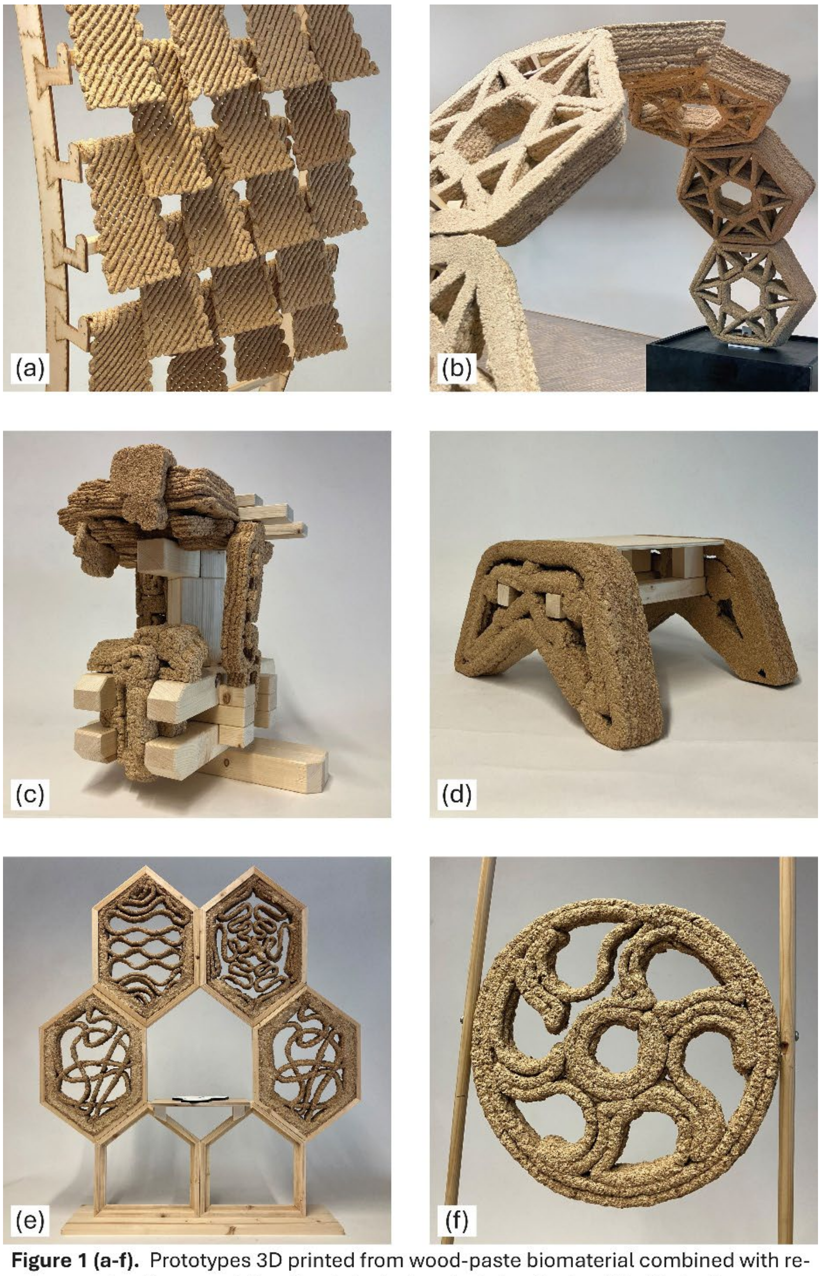

Figure 1 (a-f). Prototypes 3D printed from wood-paste biomaterial combined with regular construction wood. Results of student projects in a *Design & Build* elective course within a Bachelor of Architecture program at the University of Innsbruck, instructed by the author (all photographs by the author).

PrototypeCollage_Bauer_Kilian_01

Figure 2. Circular Material Life Cycle Diagram (diagram and all photographs by the author).

CircularMaterialLifeCycle_Bauer_Kilian_02

Acknowledgements: The author would like to thank Prof. Marjan Colletti for enabling this research through the support and infrastructure of the Robotic Experimentation Lab (REX|LAB). Gratitude is also extended to the students of the Design Build / Prototyping course in the Bachelor of Architecture program at the University of Innsbruck (summer term 2025), whose prototypes (shown in Figure 1) have made a valuable contribution to this research.

Anna Albrecht, Theo Ballauf, Anton Ballreich, Leonard Bohne, Benedikt Ehrmann, Bianca Engling, Wassilissa Falbesoner, Cornelia Gasse, Philipp Kaltschmid, Luisa Kiener, Felix Knapp, Anna Koch, Lilly Krüger, Finja-Carolyn Lembke, Kilian Lipp, Corvin Mahle, Adrián Martinko, Luis Miltner, Laurin Morell, Simon Rodriguez Schurer, Thomas Siller, Ema Solari Wasmuht, Fynn Stein, Lorik Tahiri, Herman Tavera-Chavez, Ruben Ungerathen, René Wendinger, Diana Winker, Aurel Zulali

11:51am - 12:03pm

A matter of resolution : resolution of matter

Oliver Thomas Hamedinger[1,2,3]

[1]Joyh Design; [2]Doctoral Student at university of Applied Arts Vienna; [3]External Lecturer at University of Innsbruck

Abstract

Developed within the framework of an ongoing PhD in architecture, this design research project examines how environmentally conscious design decisions that account for ideological, behavioural, material, and spatial implications can shape architecture across multiple scales. From urban morphology and building typologies to surface articulation and micro-material detail, the research positions architecture as a medium of cultural agency and ecological responsibility rather than a neutral problem-solving tool.

The project combines design theory, historical analysis, and empirical material experimentation, using contemporary digital fabrication as both a conceptual lens and an operational platform. At its centre is a series of 3D-printed sand samples to test how formal variation and geometric resolution affect environmental performance. Each component's outer facing surface is set at a specific level of detail, with LOD00 having a flat, continuous surface, LOD01 introducing moderate articulation, and LOD02 featuring higher-resolution complexity. Working across these three resolutions reveals how shifts in geometry and texture shape the material's behaviour, thereby cultivating distinct surface delineations under weathering tests.

To broaden the scope of results, components are produced by two manufacturers using different sand-printing technologies and binder systems. Additionally, these samples are treated with various coatings, such as water-repellent and UV-resistant coatings, to examine how surface treatments interact with geometry and environmental exposure. This enables an elemental comparison of how different material and design choices impact the durability of the samples, their potential for reuse, and their resistance to local meteorological conditions.

The study treats resolution not merely as a formal or aesthetic choice but as a performative and conceptual variable that informs material lifespan, spatial expression, and environmental responsiveness. Rather than dismissing ornament and surface complexity as decorative, the research positions them as critical drivers of circularity and design intention.

The theoretical framework draws on Vilém Flusser's critique of design as programmatic control, Philippe Morel's digital rationalism and modular automation, and Albert Farwell Bemis's vision of prefabricated construction. Through the synthesis of theoretical inquiry and material practice, this project proposes a model of architecture that is materially specific, ecologically informed, and critically engaged with the complexities of contemporary design.

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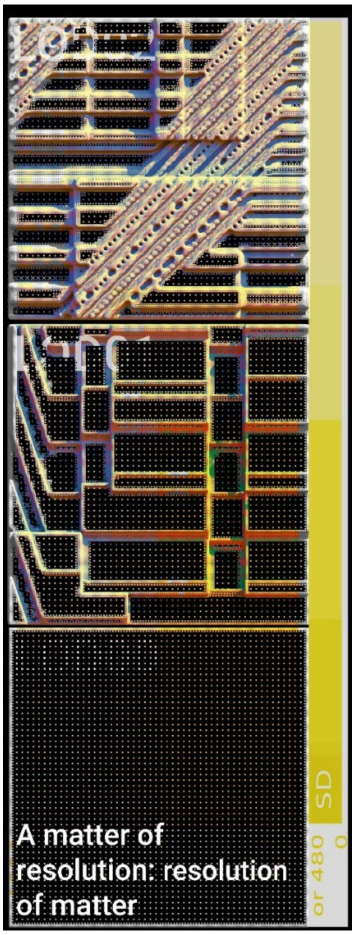
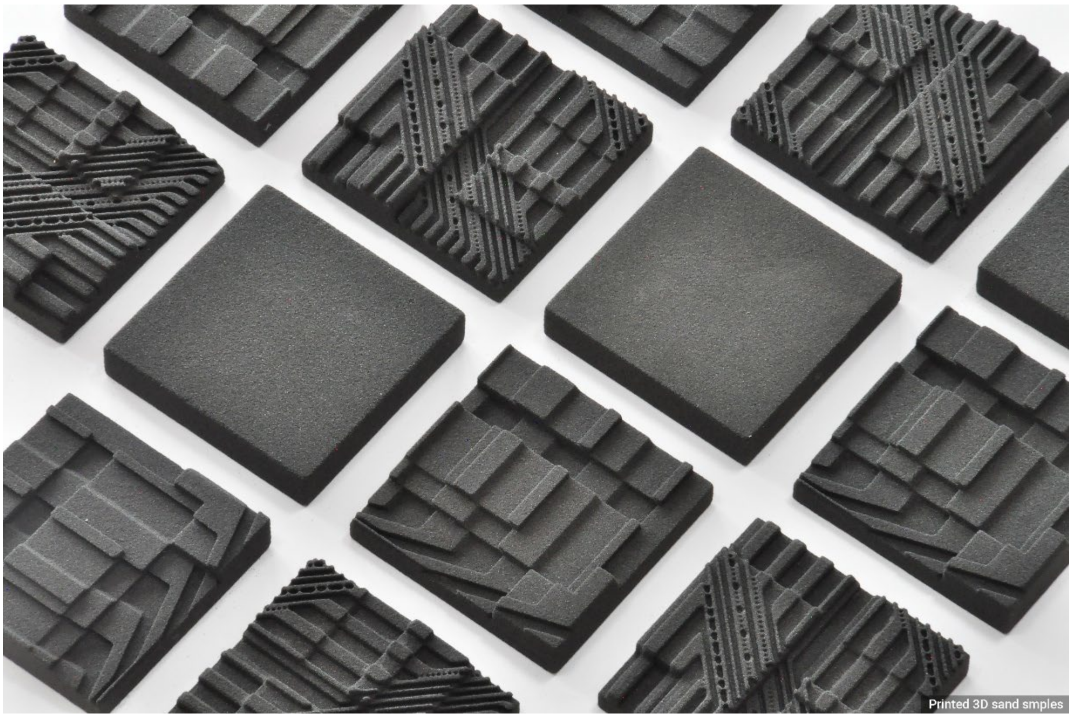


A_matter_of_resolution_Resolution_of_matter_Hamedinger_Oliver_01



A_matter_of_resolution_Resolution_of_matter_Hamedinger_Oliver_02

Session 5: Bioreceptivity

Friday, 21/Nov/2025:

1:30pm - 2:30pm

Location: **Auditorium of the University of Applied Arts Vienna**
Vordere Zollamtsstraße 7, 1030 Vienna

1:30pm - 1:42pm

When Moss Speaks: Informing bioreceptive design through mapping photosynthetic behaviour of epilithic mosses

Alexandra Adelina Lăcătușu, Marcos Cruz, Brenda Parker
University College London, United Kingdom

Abstract

Bioreceptive Design reframes building façades as dynamic, living surfaces shaped by multispecies cohabitation, where material ageing and biological growth become integral to architectural expression (Cruz, 2021; Cruz & Beckett, 2016). Mosses, particularly suited to such environments due to their poikilohydric nature, contribute to urban ecosystem services, including carbon sequestration, nitrogen cycling, and stormwater retention (Anderson et al., 2010; Elbert et al., 2012). Despite this, the precise environmental parameters that support moss development on vertical urban surfaces remain insufficiently mapped.

This research introduces a prototype monitoring instrument that integrates environmental sensor data and near-infrared imaging to study moss behaviour over time. Bridging bryology, ecological science, and digital fabrication, the system tracks physiological responses of *Syntrichia ruralis* in relation to changes in light intensity and colour, temperature, and humidity—factors known to influence photosynthetic performance (Coe & Sparks, 2014; Griffin-Nolan et al., 2018; Zotz et al., 2000; Zotz & Rottenberger, 2001).

The closed-loop chamber measures real-time CO_2 uptake and O_2 production as proxies for net photosynthesis, while NDVI and NPCI (Normalised Difference Vegetation Index and Normalised Pigment Chlorophyll Ratio Index) are extracted from sequential imaging to assess active photosynthetic regions non-destructively (Graham et al., 2006; Young & Reed, 2017). These datasets are processed via a novel Python-based program on a Raspberry Pi to visualise moss responses through time-series data and correlate physiological shifts with environmental changes.

Initial findings demonstrate measurable effects of fluctuating temperature and light conditions on moss carbon dynamics. The system enables the mapping of optimal parameters that enhance photosynthetic efficiency, providing a model for curated propagation on bioreceptive substrates. Beyond empirical results, this project proposes a tool for embedding ecological intelligence into architecture, enabling a responsive design process in which living systems co-author material choices.

By coupling digital sensing with visual proxies of plant behaviour and data sonification (Zelada & Çamcı, 2024), this prototype supports a biocentric methodology where design responds to and integrates biological organisms. It lays the groundwork for adaptive architectural strategies rooted in environmental responsiveness, biological performance, and non-human agency.

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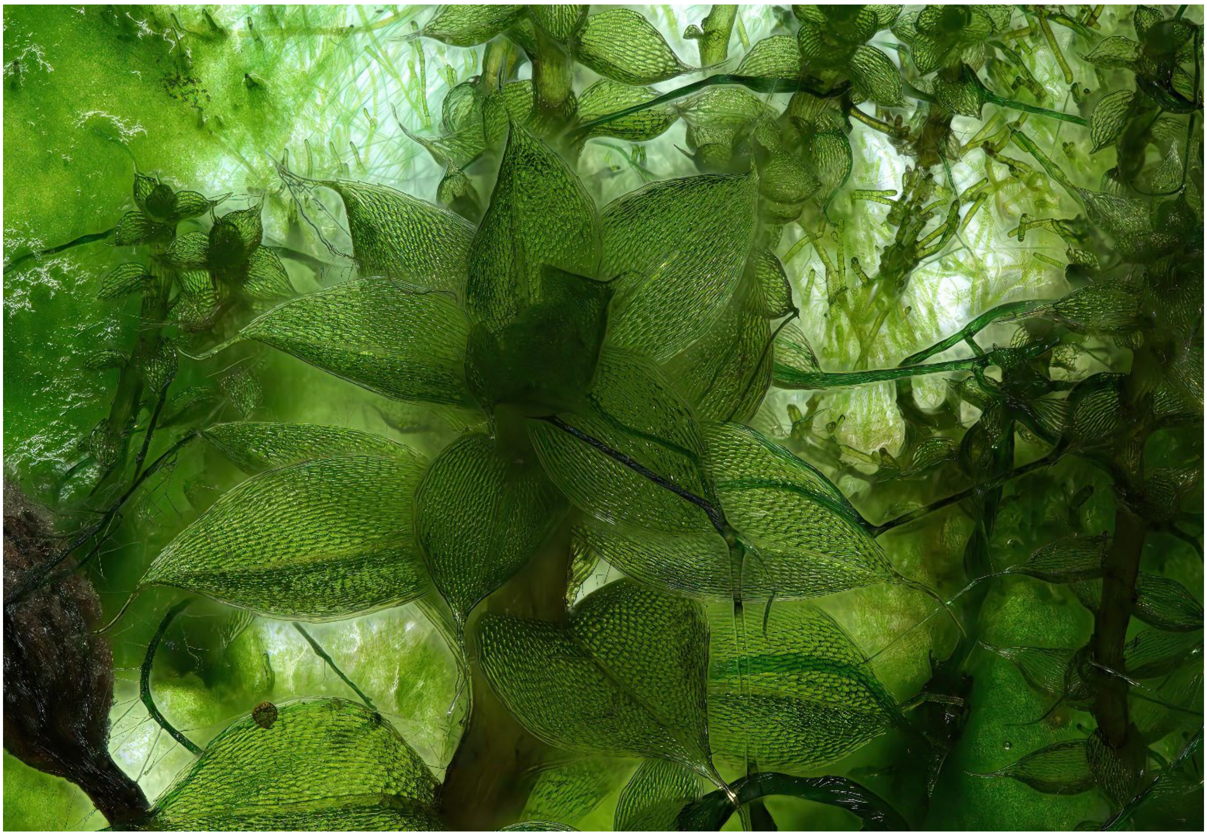
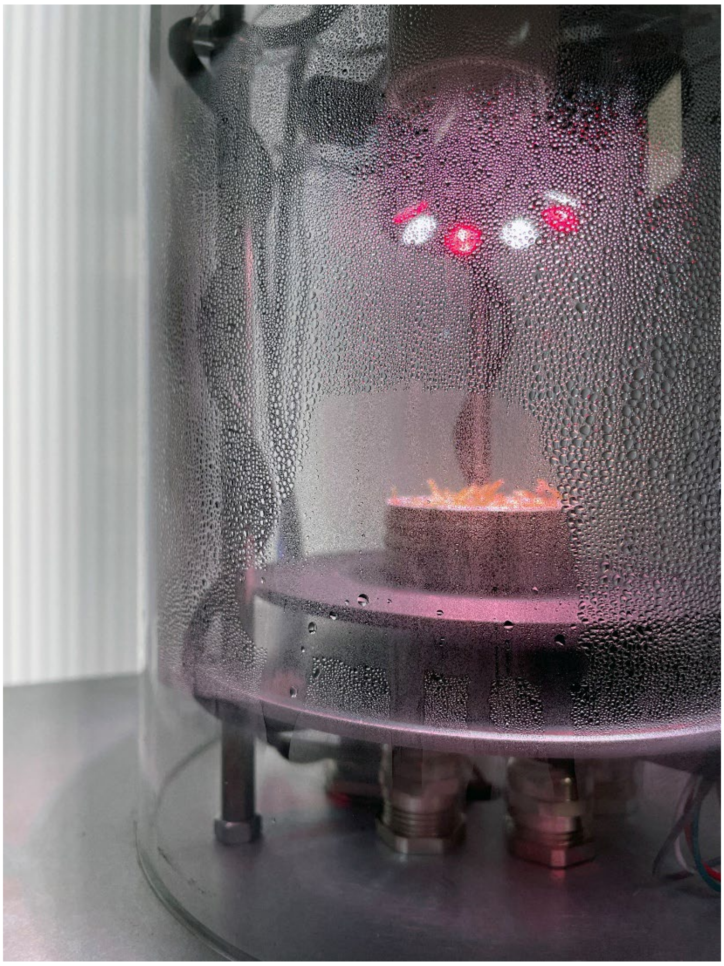


MicroForest


MossMonitoringInstrument

1:42pm - 1:54pm

Weathering as an Ecological Design Factor: An Exploration into Biogeomorphic Interactions for Enhanced Weathering of Urban Stone Structures

Maria Jose Creuheras, Nathanael Myers, Farida Radwan

University College London, United Kingdom

Abstract

Weathering is traditionally seen as a process of decay, yet it holds the potential to activate ecological functions and enhance architectural expression (Mostafavi & Leatherbarrow, 1993). This project repositions weathering as a productive ecological force that can transform buildings with aesthetic depth, material richness, and the capacity to host life. As structures age, weathering processes (chemical, physical, and biological) gradually unlock nutrients from mineral substrates and generate micro-environments capable of supporting plant and microbial colonization. This research asks how architectural design can intentionally harness weathering as a driver for ecological succession and biodiversity in urban contexts.

Central to this inquiry are three agents: phosphorus dynamics in lithic substrates, biologically enhanced rock weathering, and the use of ornamentation to generate conditions for bioreceptivity. The objective is to reconceptualize buildings as active geological-ecological systems that evolve through time and contribute to the metabolic and ecological health of cities. Through a multi-pronged approach involving lab experiments, fabrication, computation, and environmental simulation, the study explores how buildings can be designed to kickstart self-sustaining ecological processes by integrating systems as active agents that interact with natural cycles through the investigations of synthetic lichen, spontaneous vegetation, biomaterial, and capillary rise.

Organisms that inhabit lithic environments exhibit adaptations to nutrient scarcity and extreme conditions, playing a critical role in mineral cycling (Yusuf, 2020). Phosphorus, an essential and finite nutrient for plant growth, is locked within mineral substrates such as limestone—commonly used in construction—but becomes bioavailable through microbial metabolism (Porder & Ramachandram, 2013). This, in combination with the utilization of classical architectural motifs, is reconfigured to create new biogenic forms that prioritize diverse microclimates and colonization of microbes and plants. Decorative elements with complex geometries then generate niches that modulate environmental conditions and are strategized to direct nutrient distribution.

By rethinking urban surfaces and leveraging innovative substrates and microbial interactions, this research proposes a new paradigm for biologically integrated architecture by rethinking urban surfaces and leveraging innovative substrates and microbial interactions, strategizing systematic design through nutrient flows. By embedding life into our constructed landscapes, architecture can foster deeper connections between built structures and their ecosystems, redefining aesthetics and functionality through ecological resilience.

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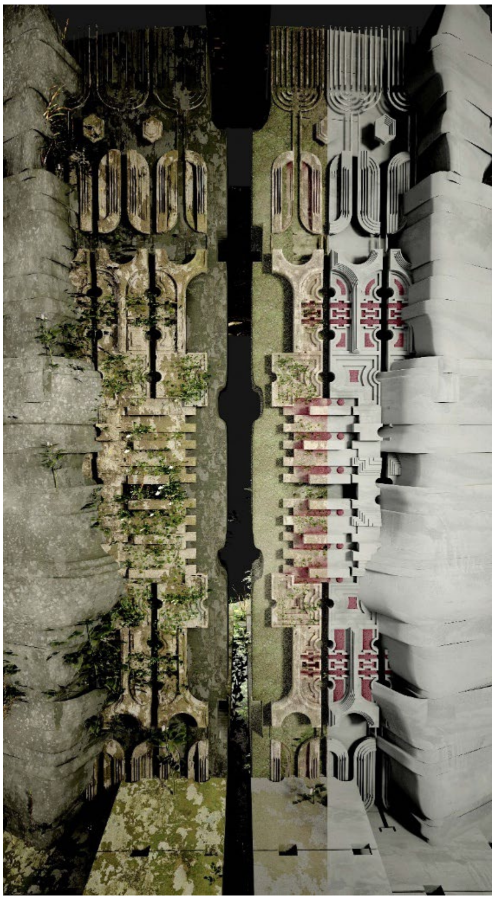

Fig 1: FertileFluxes_WeatheredPrototype_092024_Jose_Creuheras,Myers,Radwan

Fig 2: FertileFluxes_WeatheringRender_Jose_Creuheras,Myers,Radwan

1:54pm - 2:06pm

BioDiverseCity: Bioreceptive Surfaces for Urban Ecologies

Sneham Pandey

Graduate from Institute of Advanced Architecture of Catalonia, Barcelona

Abstract

Cities have long been designed as exclusive habitats for humans, often diminishing space for other life forms. However, recent work in urban ecology shows that cities can support surprisingly high biodiversity. Urbanization creates physical and chemical barriers that fragment ecosystems, and one such overlooked barrier, but also a site of opportunity, is the architectural surface. While nature-based solutions often address green and blue infrastructure, buildings themselves are rarely explored as active contributors to biodiversity. This thesis addresses that gap by reimagining building facades as bioreceptive membranes—living interfaces embedded with ecological potential.

Drawing on the concept of “architectural bark”, the study investigates how poikilohydric organisms like mosses and lichens can colonize building surfaces. The research followed four phases: defining the Client (organism), selecting the Host (substrate), shaping the Design (morphology), and choosing the Tool (fabrication method). Emphasis was placed on locally sourced, bio-based materials from waste streams to support circularity. Scaffold geometries were designed to enhance colonization through surface complexity, shading, and water retention. Additive manufacturing was selected over casting and molding for its ability to create micro-grooves that increase porosity and support biofilm attachment.

A prototype cladding panel was fabricated using cork and charcoal using the multi-material additive manufacturing technique developed at IaaC. Cork provided structure and insulation, while charcoal introduced bioreceptive zones in a functionally graded composite. Serving as a proof of concept for bioreceptive retrofits, the panel demonstrates the viability of creating ecologically responsive surfaces. Though small in scale, it is envisioned for application in retrofit buildings, aligning with zero-carbon renovation strategies in cities like Barcelona.

This early-stage research confirms the material and fabrication feasibility of bioreceptive surfaces, while highlighting the need for long-term assessment of ecological colonization, climatic resilience and architectural integration. The prototype demonstrates how bio-based, additively manufactured components can support ecological connectivity and enhance urban biodiversity. Positioned at the intersection of biology, technology, and architecture, the study reframes the building envelope as a symbiotic membrane—an infrastructure of care and cohabitation. As a scalable pilot, the prototype outlines both the potential and next steps for embedding aliveness into urban construction.

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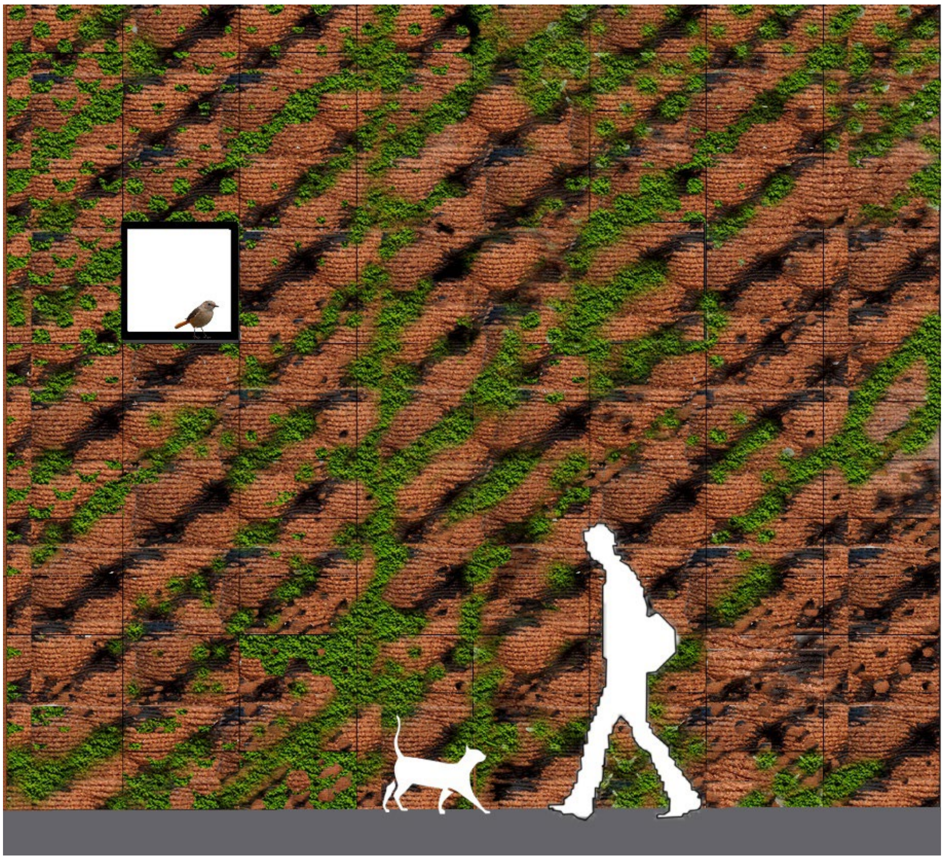
Prototype_Pandey_Sneham_01



UrbanApplication_Pandey_Sneham_02

2:06pm - 2:18pm

Water-Driven Membranes: Methods of Activating the Building Envelope for More-Than-Human Commoning.

Dimitra Almpani-Lekka[1,2], Yannis Zavoleas[1,3]

[1]Department of Architecture, School of Engineering, University of Ioannina; [2]Cluster of Excellence 'Matters of Activity', Humboldt-Universität zu Berlin; [3]Faculty of Arts, Design & Architecture, University of New South Wales

Abstract

This research project investigates methods for designing building envelopes activated by greywater to integrate the built environment into the functions of the ecosystem. The building envelope is approached as both an interface and a regenerative infrastructure for multispecies commoning by addressing the connected issues of urban water management, climate resilience, air and water pollution, as well as the loss of urban biodiversity caused by resource pollution and habitat fragmentation. The project explores design methods of harvesting, circulating, storing, and bioremediating greywater to increase bioreceptivity, aiming to create circular thermodynamic and biochemical chain reactions that benefit multiple levels of biodiversity and humans alike. From hand-building vertical clay-based landscapes, to utilizing digital hydrodynamic form-finding tools, the project combines analogue and digital design and fabrication, along with embodied, empirical, and scientific forms of knowledge, to enrich the architectural design process. Using biotechnological tools of production and monitoring, the aim is to promote the growth of specific biofilms and bryophyte species capable of efficient oxygen production, carbon dioxide fixation, and water bioremediation. The living biomass can in turn mitigate the effects of urban heat and create an approximate micro-climate of comfort for multiple species. This vibrant bio-protective layer functions in synergy with an overlapping system embedded in the envelope, providing commons such as habitat, nutrition, and survival resources to local keystone species of fauna and flora. The project draws on morphological and organizational principles of mutualistic relationships in nature, especially the relationship between poriferans and their endosymbionts, while also addressing the potential for predation and conflict among species, bridging architecture and urban ecology. Informed by landscape architecture, the envelope is intended as an experimental vertical field where multimodal and more-than-human care practices can unfold. This approach shifts architectural design from a predictive process seeking control and stability to a dynamic process of learning from biological agency and designing systems capable of biological adaptation and interaction in a physical world that is rapidly changing.

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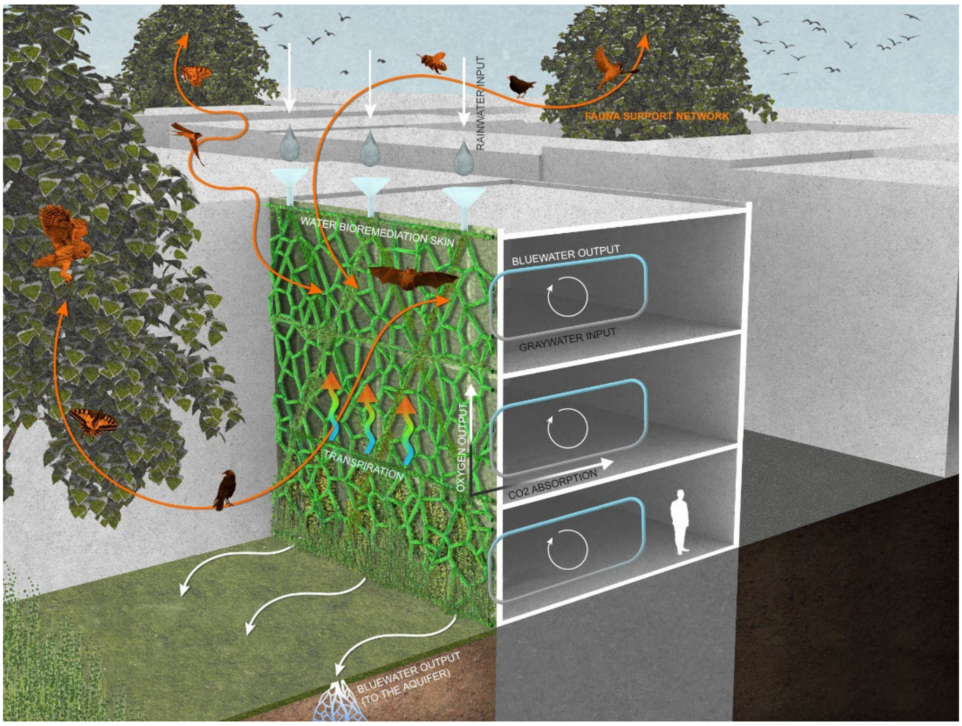
Bioreceptive_tile_modules_Almpani-Lekka_Dimitra_02



Diagram_Bioreceptive_Envelope_Almpani-Lekka_Dimitra_01

Session 6: Critical reflection

Friday, 21/Nov/2025:

2:45pm - 3:45pm

Location: **Auditorium of the University of Applied Arts Vienna**
Vordere Zollamtsstraße 7, 1030 Vienna

2:45pm - 2:57pm

Resilience-by-Design: confronting the environmental crisis via architecture.

Stefano Corbo

Delft Institute of Technology / Faculty of Architecture and The Built Environment, Netherlands. Chair of Public Building

Abstract

According to the Netherlands Environmental Assessment Agency, 55% of the Dutch land surface is at risk of flooding – 26% of the country is below sea level, and 29% is potentially susceptible to river flooding. If since 1900 sea level rise of the North Sea near the Dutch coast has been 19 cm, which is comparable with the global average, over the last decades, sea level rise near the Dutch coast has increased to 3 mm per year, an increase by 50% compared with the average rate of sea level rise over the 20th century.

In acknowledging the challenges caused by climate change, different educational initiatives have recently taken place across the country to investigate urban and architectural solutions. Among those, is “Resilience by Design”, a pedagogic model implemented at TU Delft, Faculty of Architecture, within the Public Building Group.

This proposal will illustrate the principles, the tools and the architectural examples of “Resilience-by-Design”. In Resilience-by-Design, climate change is studied and investigated at the scale of architecture – that is, the design of the buildings: how buildings can prepare for climate change, how their structure can adapt to uncertain scenarios, what spatial and material characteristics they need to acquire in order to resist shocks. Students learn concrete principles: adaptability, reuse, modular expansion, disassembly, flexibility. Each of those principles implies different techniques and design decisions – clear spans, generous floor-to-floor heights, flat floors, interior non-load-bearing partitions, raised corridor / circulation, water storage, wet-proofing materials, exposed connections, use of mechanical fasteners. In applying those and other decisions, students acknowledge the importance of designing for and with climate change, and familiarize with innovative design strategies which favor reuse rather new constructions, sustainability rather than land consumption.

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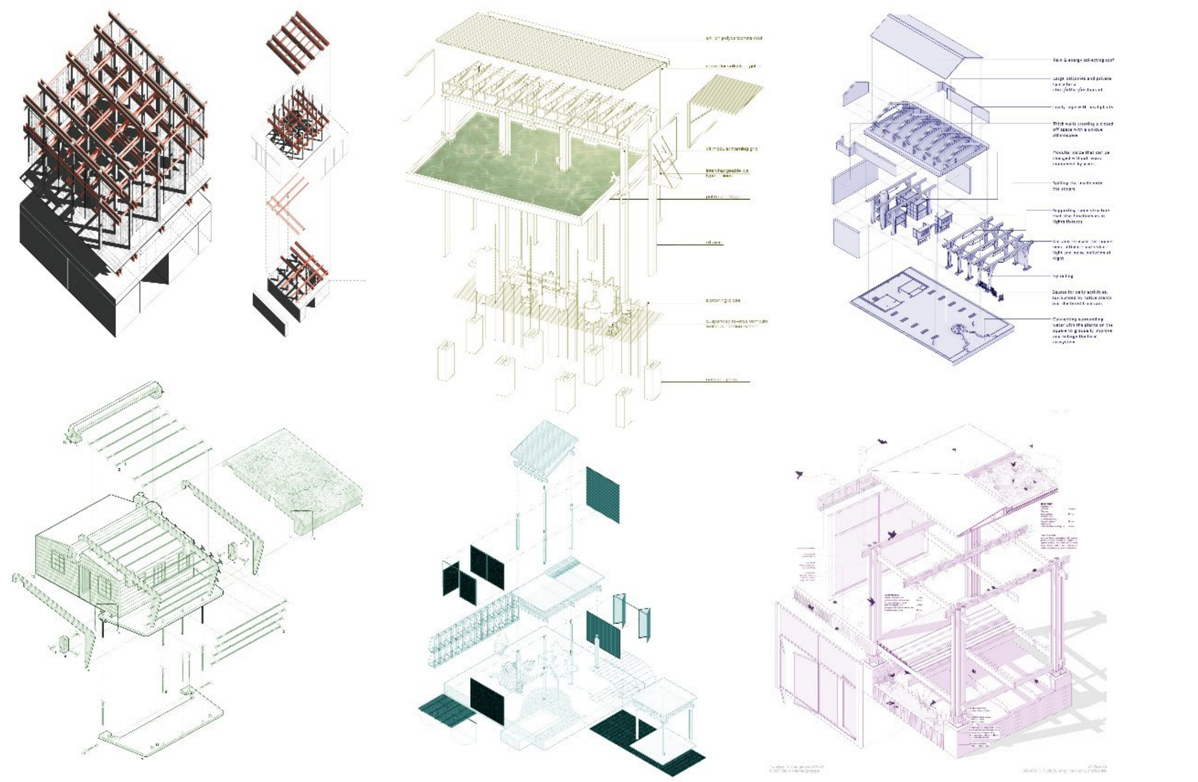

Fig. 1. MSc. 2 Design Studio “Resilience by Design”, Faculty of Architecture and The Built Environment – TU Delft. *Resilient Prototypes.* Students: William Chen, Lucas Jourdain, Lala Leung, Mary Perez, Isabel Roden, Stella Antonia Sprenger. Teachers: Stefano Corbo, Sien van Dam

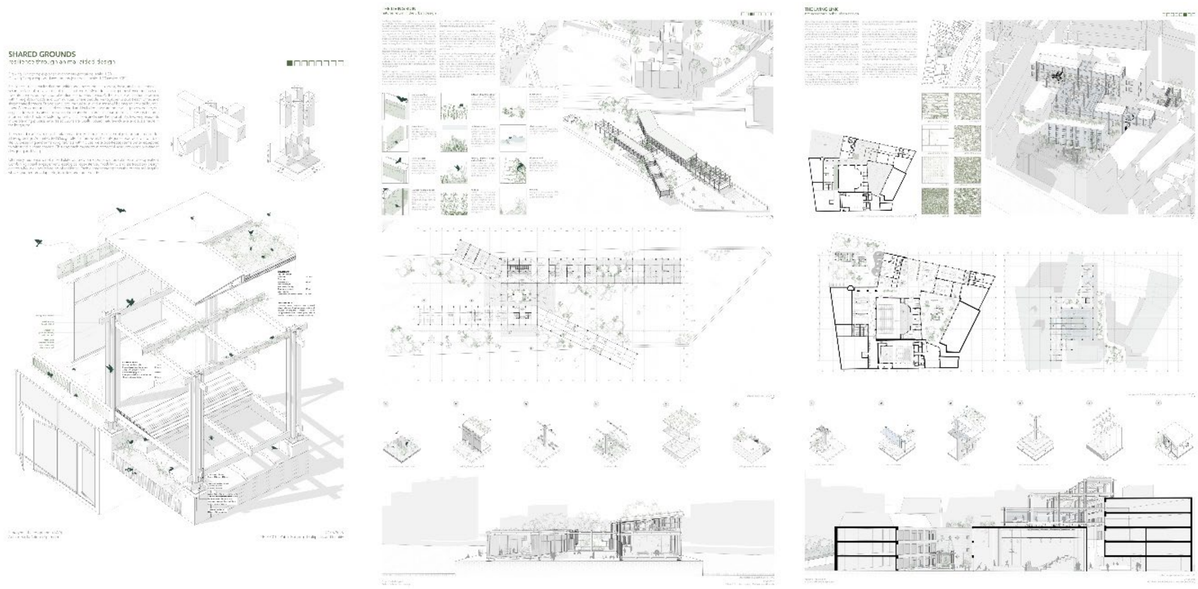

Fig. 2. MSc. 2 Design Studio “Resilience by Design”, Spring 2025, Faculty of Architecture and The Built Environment – TU Delft. *From Prototyping to Building.* Student: Stella Antonia Sprenger. Teachers: Stefano Corbo, Sien van Dam

2:57pm - 3:09pm

Meeting Salmon in Elevators: Fish, Infrastructure, and Ecological Imagination in the Northern Black Forest

Bastian Schleier

Academic and Research Department for Artistic Methods, RWTH Aachen, Germany

Abstract

The story of salmon migration in the river Murg in the Northern Black Forest reveals shifting conceptions of aliveness across 200 years of industrial transformation in the Murg Valley, beginning in the 19th century. Rather than portraying the landscape as a passive backdrop, this project investigates it as a living archive of infrastructures, ecological systems, and media technologies. Following the transition from a craft-based to an industrialized fluvial economy, a series of technological thresholds are examined as temporal entry points to explore how infrastructures fundamentally altered biological, ecological, and socio-cultural networks. Cultural perspectives, from Wilhelm Hauff's tale *Das kalte Herz* to a contemporary initiative promoting a salmon-themed hiking trail, illustrate how socio-ecological imaginaries of the valley intertwine with its technical and ecological realities.

Central to the investigation is a critique of the persistent romanticization of rural environments through their perceptual division into active, living subjects and passive, objectified matter. Drawing from media studies, philosophy of technology, and ecological humanities, infrastructures are explored as living rejections of such dichotomies.

As the river was restructured for paper production and hydroelectric dams, infrastructures disrupted ecological flows, integrating it into a technical environment and blocking the salmon's native spawning grounds. Today, however, the relation between technological and biological patterns of life has been reimagined, and the implementation of fish staircases has enabled the salmon's successful reintroduction to the region. Thus, arriving at a more holistic conception of aliveness is key to moving beyond exclusionary or extractive conceptions of "nature". The salmon's return depended not only on ecological restoration but also on cultural and conceptual shifts: infrastructures must be understood as milieu-specific agents, integral to natural environments and capable of enabling and foreclosing existence for a broad range of beings.

Ultimately, the Murg Valley serves as a case study for broader questions of care, remediation, and ecological imagination in the Anthropocene. Integrating scientific and artistic methods, the project contributes to architectural research on how to reconceive the relations between landscapes, nature, and technology. It demonstrates how acknowledging aliveness can cultivate more inclusive strategies of restoration, cohabitation, and the design of livable futures.

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TheupperdamatKirschbaumwasen_Schleier_Bastian_01

TheSchwarzenbachtalsperreanditsnewuses_Schleier_Bastian_02

3:09pm - 3:21pm

Fermenting Architecture

Luisa Zwetkow

non, Austria

Abstract

"Architecture is the daughter of agriculture."
This phrase reveals an ancient truth: agriculture allowed humans to settle, to build, to shape culture. Through food, we developed a deep relationship with our environment: a direct, bodily understanding of place, season, and material. Food grounds us. Shouldn't architecture do the same?
Farmers, bakers, and fermenters develop deep knowledge through touch, smell, and time. Their work is shaped by context, not imposed upon it. This is the kind of relational, adaptive intelligence architecture needs.

Fermentation, in particular, embodies this shift. It's an ancient method of transformation, not through domination, but through collaboration with microorganisms, time, temperature, and material. It cannot be rushed. It resists control. Yet its outcomes are rich, complex, and enduring. What if building were more like fermenting?

We need to rethink the architectural process: the roles, the actions, the hierarchies. Move away from rigid control and toward participation, from acceleration to attunement. Fermentation teaches us to work with what exists, to allow things to evolve, to embrace uncertainty and change. Its slowness is not inefficiency, it's a kind of care that leads to longevity, quality, and depth.

Like a baker who knows by hand when the dough is ready, architects need tacit knowledge, an intuitive, material understanding built through experience. This is not a return to the past, but a way forward: grounded, responsible, connected.

A fermentative culture of practice redefines architecture as an open, non-linear process. Practices such as studio dreiSt e.g. demonstrate how waste cycles and collective reassembly can carry experimental approaches into first applications. Material, time, and context unfold as feedback loops during the design and construction phase, nourishing the work with knowledge as it emerges. This also means to adapt the design in response to material actual behave, rather than forcing them into predetermined forms. Each process is both continuation and renewal, embedding building within ecological and social metabolisms that regenerate themselves. In this sense, fermentation offers architecture a framework that complements, rather than replaces, conventional approaches: the aim is less to deliver fixed objects than to establish conditions that remain open, adaptive, and relational.

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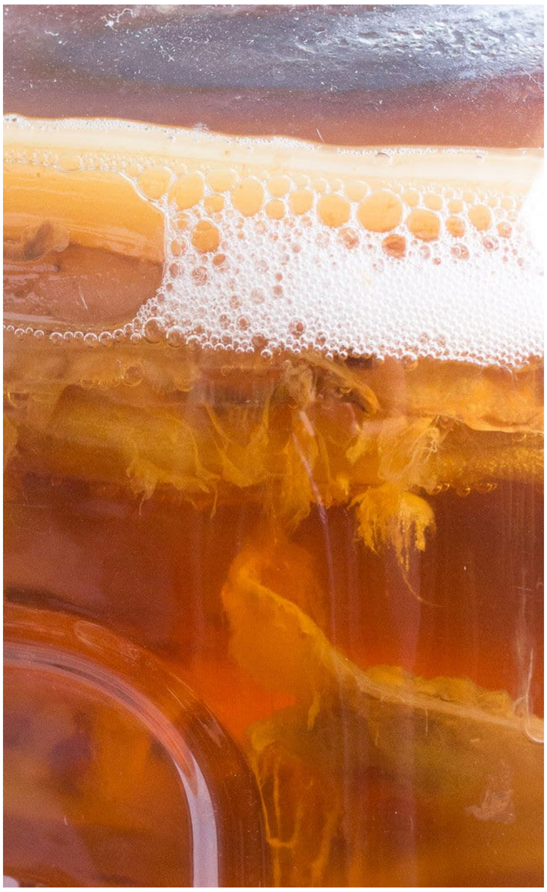

Continuous-Brew-Kombucha-3

3:21pm - 3:33pm

Designing for Deep Time: Regenerative Longevity through Multispecies-Maintenance

Paul J. J. Treichl

Department for Planetary Education, United Kingdom

Abstract

Traditional approaches to longevity in the built environment emphasise durability, permanence, resistance to decay, and minimal maintenance. Maintenance is treated as a technical afterthought, removed from the work of planners, and increasingly, also the inhabitants. I challenge that paradigm by advancing *multispecies-maintenance* as a framework for regenerative longevity. Rather than preserving structures as static fortresses, this means understanding them as living assemblages sustained through continuous transformation of repair, decomposition, and adaptation by humans and non-humans alike.

Drawing on maintenance studies, material cultures, and Morton's notion of the *hyperobject*, I argue that maintenance operates as a temporally vast, distributed process that exceeds human control and understanding. Thus, collective maintenance of our built environment by all living organisms must become a fundamental, situated consideration in all stages. Fungi, mosses, microbes, and other organisms already perform maintenance, regulating humidity, repairing soils, and decomposing matter. These are not metaphors but ecological realities that sustain our environment. Multispecies-maintenance offers a paradigm shift by viewing maintenance as active collaboration between humans and non-humans. Instead of positioning architecture as separate from ecological processes, it integrates living organisms as active stakeholders, fostering symbiotic structures that engage with living networks. This perspective challenges existing norms where layers remain rigidly separated and controlled, in contrast to the entanglements found in natural systems. Thus, multispecies-maintenance becomes how buildings participate in life, rather than shield against it. It opens the potential to redistribute labour across species, countering the commodification and rigid separations that define current practices and ownership.

Unfortunately, fetishisation of novelty, "purity", and capital neglects the behavioural shifts necessary for implementation and currently offers no examples. Thus, my argumentations sit in a space of critical theory and negative capability. What it offers is a methodology, a new palimpsest vernacular, collaborative, inter-species architecture, rebuilding the relationship between the environment and its inhabitants by reconstituting the genius loci eroded by capitalist commodification.

The necessary shift is examined in two phases: The Now, a messy transitional space for unlearning and interim materiality; and The Future, where maintenance, decay, and biological intelligence are embedded at conception into architectural systems and computational/material logic.

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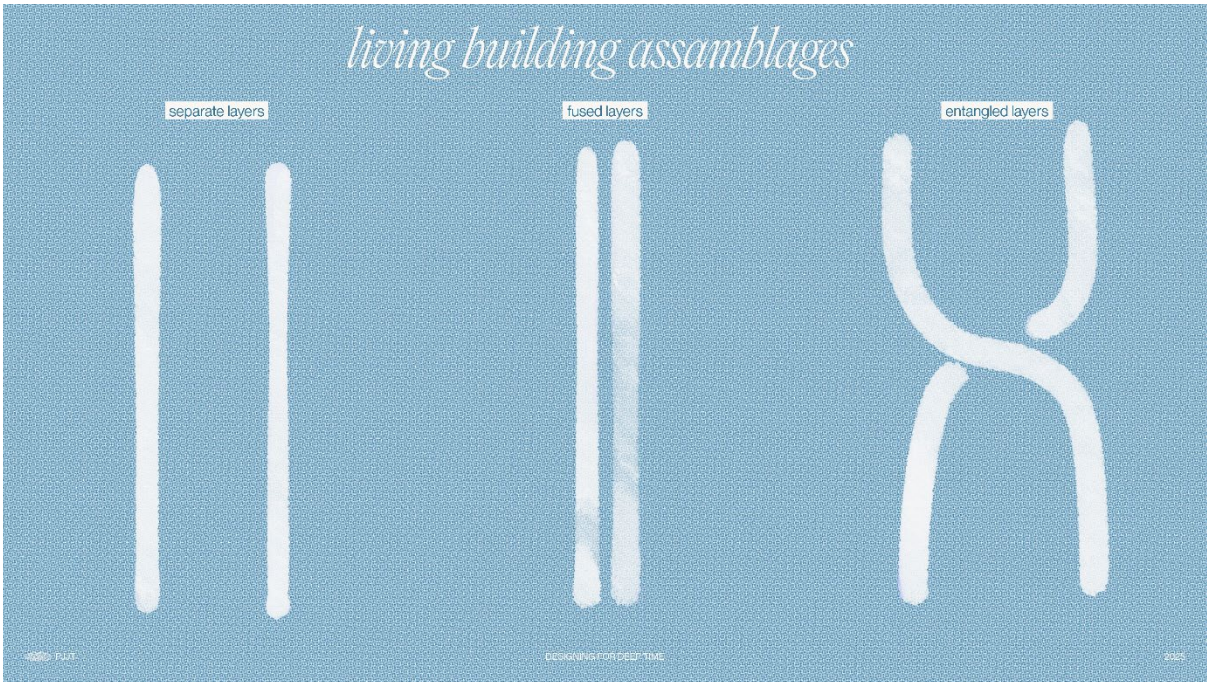

Living_Building_Assamblages_treichl_paul_01

Multispecies_World_Making_treichl_paul_02

3:33pm - 3:45pm

Edifical Dark Earth: Microbially Inoculated Carbonaceous Architectures

Timothy Ryan

Lyse, United Kingdom

Abstract

Across Amazonia, ancient sites have been discovered whose dark soils demonstrate exceptional fertility. Locally known as terra preta, these sites originate as far back as 2500 BC and exist in stark contrast to common weathered latosols of the tropics. Riddled with bones, ceramic shards, and lithic fragments, these soils are no result of natural phenomena, but rather the formative by-product of ecologically-integrated societies. Attuned to the cycles of decomposition, indigenous societies had developed complex forms of semi-domesticated agroforestry that reworked vegetal and animal refuse back into the earth. Their soil was not merely a forum for extraction, but rather a terrestrial legacy that was actively cultivated. At the heart of this relationship is the employment of pyrolysis, a form of anaerobic ‘fire’ that thermally decomposes organic matter into stable forms of carbon that persist in the soil for millenia . Edifical Dark Earth is the architectural translation of terra preta. Imbued within ceramics, biogenic carbon builds upon a rich legacy of earthen structures to create a novel hybrid of ancient materials. These carbonaceous structures utilise carbon’s microscopic properties to absorb atmospheric pollution, filter contaminated water, and increase soil fertility. Carbon becomes an architectural material, whose intricate porosities reflect an intra-scalar approach to space making. Not only does this represent a durable, scalable method of carbon sequestration, it also harnesses the intrinsic properties of biological matter into ecologically active buildings. Perhaps most significantly, these materials can be inoculated and therefore, microbially active. Their interconnected porosities enable water retention and efficient nutrient adsorption, allowing bacteria, mycorhizzal funghi, and other microorganisms to flourish deep within them. Architecture becomes substrate, where microbial inoculations can even be tailored towards medical or agricultural receptions (i.e. using nitrogen-fixing diazotrophs to reinforce soil fertility in agrarian contexts). Inert materials suddenly become mediums of fecundity, upheaving traditional conceptions of the city as a place of non-nature. These architectures are not only made of biological matter, they cultivate living ecologies within architectural terroirs that resituate humans into multispecies urbanities.

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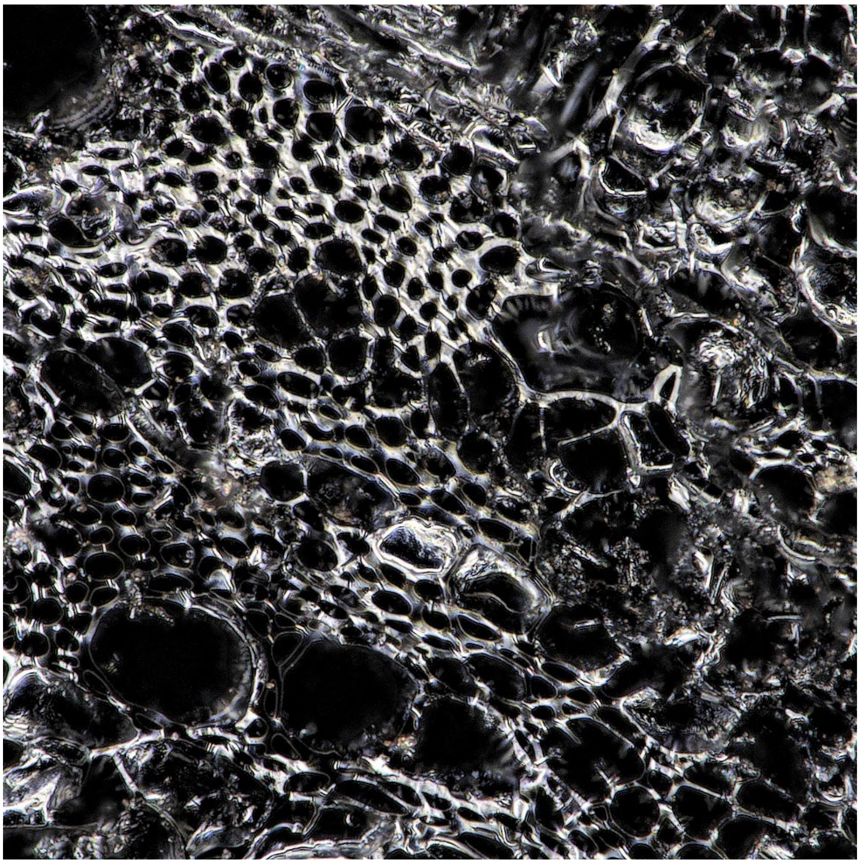
Image References:

Microscopy in collaboration with Julian Rodriguez Jirau


Image_Ryan_Timothy_01


Image_Ryan_Timothy_02

Posters

Thursday, 20/Nov/2025:

4:00pm - 6:00pm

Location: **Auditorium of the University of Applied Arts Vienna**
Vordere Zollamtsstraße 7, 1030 Vienna

Living Tectonics As Micro-Contextual Strategies

Büşra Ağaç[1], Fitnat Cimşit Koş[2]

[1]Gebze Technical University, Turkiye; [2]Gebze Technical University, Turkiye

Abstract

The study hypothesises that algorithms produced through collaboration between bodies enable context to become reproducible in architecture. In other words, if there is a body, there is a relationship; if there is a relationship, there is a context. The connection produced through the relationship between bodies offers living relationships that are constantly produced, rather than being given beforehand.

The study aims to examine the productivity of context by investigating the intricate interactions of concept, representation, and production, specifically focusing on the mechanisms of resistance and adaptation that natural organisms develop against the physical environment.

In the study, plants growing on the pavement were chosen as an example of micro-context, since they thrive under challenging conditions with limited possibilities and develop strategies such as rooting into narrow gaps to access nutrients. This micro-context was analysed through research by design, employing three complementary methodologies: algorithmic variation -modelling behavioural codes parametrically with Grasshopper, operational diagramming -conceptual visualisation of these behaviours, developed through the Midjourney AI tool, and operational materialisation - testing 3D printing strategies in Bambu Studio to translate digital parameters into analogue materialisations.

Starting from the idea that for a formation to be considered living, it must not only possess a physical presence but also establish a dynamic relationship with its environment, develop active behaviors under its own unique conditions, and adapt to environmental differences, nine behavioral codes have been identified: accumulation, embracing, carving, attachment, orientation, spreading, densification, adaptation, and transformation. To derive these behavioural codes, research by design methods were applied to the selected micro-context. When the behavioural reading of the digital representations was conducted, it was observed that not only the targeted behavioural codes emerged, but also various intermediate states. These in-between states indicate that the system does not proceed in a single linear direction (input-output), but rather evolves with an open-ended, pluralistic approach. Therefore, the micro-context can be understood not as a single form, but as a tectonic vitality encompassing multiple formations within itself.

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Büşra AĞAÇ, Fitnat CİMŞİT KOŞ
Gebze Technical University

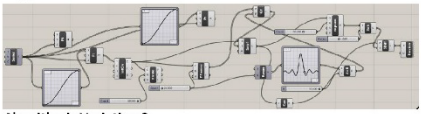
Living Tectonics As Micro-Contextual Strategies

The hypothesis of the study is that algorithms produced through collaboration between bodies enable context to become reproducible in architecture. In other words, if there is a body, there is a relationship; if there is a relationship, there is a context. The connection produced through the relationship between bodies offers living relationships that are constantly produced, rather than being given beforehand.

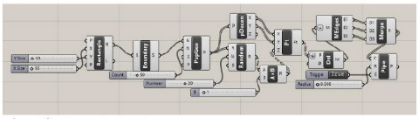
The study aims to examine the productivity of context by investigating the intricate interactions of concept, representation, and production, specifically focusing on the mechanisms of resistance and adaptation that natural organisms develop against the physical environment.

In the study, plants growing on the pavement were chosen as an example of micro-context, since they thrive under challenging conditions with limited possibilities and develop strategies such as rooting into narrow gaps to access nutrients. This micro-context was analysed through research by design, employing three complementary methodologies: (1) algorithmic variation—modelling behavioural codes parametrically with Grasshopper, (2) operational diagramming—conceptual visualisation of these behaviours, developed through the Midjourney AI tool, and (3) operational materialisation—testing 3D printing strategies in Bambu Studio to translate digital parameters into analogue materialisations.

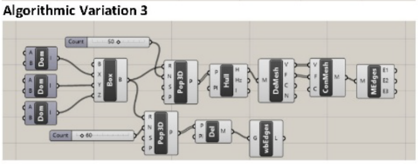
Algorithmic Variation 1

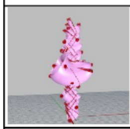
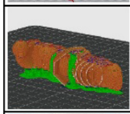
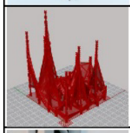
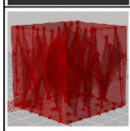


Algorithmic Variation 2



Algorithmic Variation 3



	Research by Design	Code-Prompt	In-between States	Behaviour Codes
	Algorithmic Variation 1	Pframes Cap B count	Compression	Accumulation, Densification
	Operational Materialization 1	Support: Tree Angle: 15	-	Enclosing/ Embracing
	Operational Diagramming 1	Compression, Densification, Surface Tension	Diffuse	Orientation, Adaptation
	Algorithmic Variation 2	Pop Geo	Organic, Responsivie, Organizable	Attachment
	Operational Materialization 2	Support: Tree Angle: 15 Transition Axes	Branching	Attachment
	Operational Diagramming 2	Branching, Porous	Articulation, Elongation	Spreading, Enclose, Wrapping, Carving, Attachment, Adaptation
	Algorithmic Variation 3	Po3d	Network Structure, Connection Points	Densification, Attachment

Starting from the idea that for a formation to be considered living, it must not only possess a physical presence but also establish a dynamic relationship with its environment, develop active behaviors under its own unique conditions, and adapt to environmental differences, nine behavioral codes have been identified: accumulation, embracing, carving, attachment, orientation, spreading, densification, adaptation, and transformation. To derive these behavioral codes, research by design methods were applied to the selected micro-context.

When the behavioral reading of the digital representations was conducted, it was observed that not only the targeted behavioral codes emerged but also various intermediate states. These in-between states indicate that the system does not proceed in a single linear direction (input-output), but rather evolves with an open-ended, pluralistic approach.

Observing intermediate states is as important as achieving the desired behavioural code, as these states reveal the system's resistance points, flexibility, and multifaceted formations, all of which play a role in the formation of the micro-context. Therefore, the micro-context can be understood not as a single form, but as a tectonic vitality encompassing multiple formations within itself.

Trace Terra

Sarvin Farhangi, James Lang
UCL, United Kingdom

Abstract

This research investigates how microbial life and natural materials can be used together to support the ecological regeneration of arid environments. Focusing on the Tabernas Desert in southeastern Spain, the study combines laboratory- grown microorganisms with biodegradable materials to stabilise soil, retain moisture, and begin the early stages of ecological recovery. The project centres on the cultivation of cyanobacteria, including Nostoc commune, alongside nitrogen-fixing bacteria and soil- stabilising actinomycetes. These organisms were introduced to sandy soil substrates and monitored for their ability to form biological soil crusts; thin, living layers that can prevent erosion and promote plant growth. In parallel, hydrogel-based materials and bio-based binders were tested for their ability to retain water, support microbial life, and gradually return to the soil. To integrate these systems at a structural level, adaptive wall modules were designed and fabricated using low-energy extrusion methods. These walls are composed of layered, biodegradable materials that allow for microbial colonisation while passively moderating temperature and humidity. A set of small-scale demonstrators was built and tested under controlled environmental conditions to evaluate their performance. While these modules have not yet been deployed in outdoor field settings, their development marks a step toward regenerative structures that work with, rather than against, local ecosystems.

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Sarvin Farhangi- James Lang
Bartlett, UCL

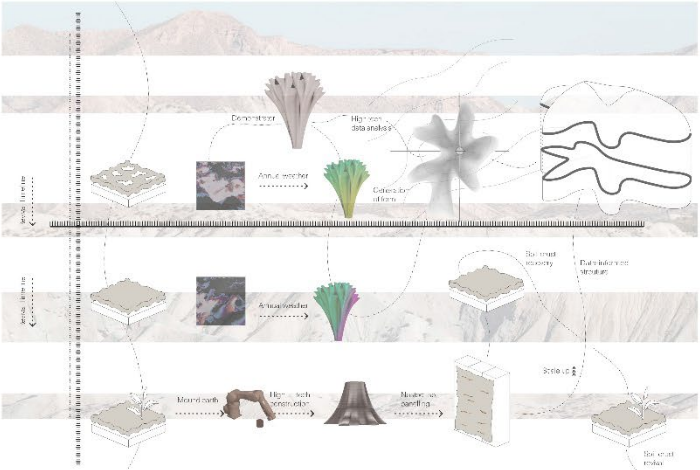
Trace Terra

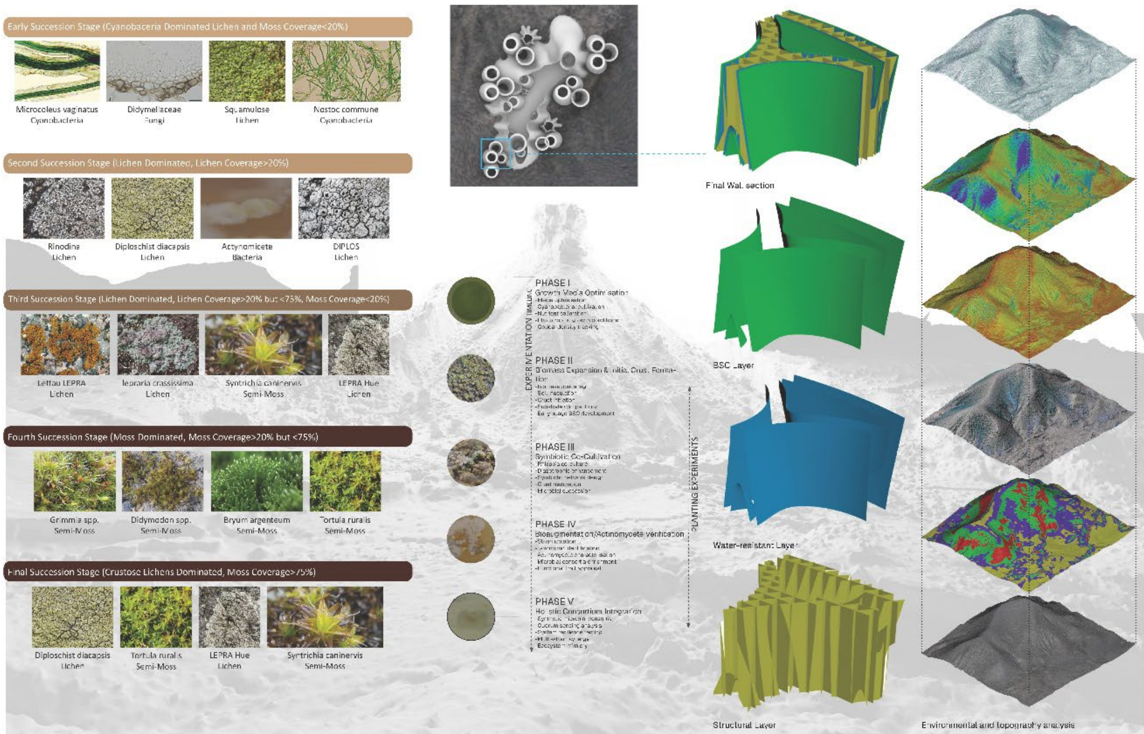
Awakening the soil for futures to come

This research investigates how microbial life and natural materials can be used together to support the ecological regeneration of arid environments. Focusing on the Tabernas Desert in southeastern Spain, the study combines laboratory-grown microorganisms with biodegradable materials to stabilise soil, retain moisture, and begin the early stages of ecological recovery.

The project centres on the cultivation of cyanobacteria, including Nostoc commune, alongside nitrogen-fixing bacteria and soil-stabilising actinomycetes. These organisms were introduced to sandy soil substrates and monitored for their ability to form biological soil crusts; thin, living layers that can prevent erosion and promote plant growth. In parallel, hydrogel-based materials and bio-based binders were tested for their ability to retain water, support microbial life, and gradually return to the soil.

To integrate these systems at a structural level, adaptive wall modules were designed and fabricated using low-energy extrusion methods. These walls are composed of layered, biodegradable materials that allow for microbial colonisation while passively moderating temperature and humidity. A set of small-scale demonstrators was built and tested under controlled environmental conditions to evaluate their performance. While these modules have not yet been deployed in outdoor field settings, their development marks a step toward regenerative structures that work with, rather than against, local ecosystems.





360+ LAB: Planýrka as a Platform for More-than-Human Urban Strategies

Kateřina Singer[1], Tamara Spalajković[2], Marek Hlavička[1]

[1]Faculty of Architecture BUT, Czech Republic; [2]Faculty of Fine Arts BUT, Czech Republic

Abstract

Planýrka, located in Brno, Czech Republic, is a mosaic of vague terrains—neglected, undefined urban spaces shaped by interrupted development and ecosystem succession. Despite their marginal status, these terrains offer critical ecological value and represent a living laboratory for rethinking urban strategies allowing for both human and more-than-human perspectives.

Planýrka serves as the foundational case study for 360+ LAB, a newly established platform initiated by a multidisciplinary group of doctoral students from Brno University of Technology. The lab is at the beginning of a long-term, open-ended exploration of alternative (non)planning approaches that move beyond human-centered development models. Its activities unfold across three interconnected layers:

Research: Planýrka provides an in situ environment for monitoring postcultural urban landscapes and nonhuman agencies. One of the key strategies is artistic research, exploring how video art can shape perceptions and narratives around neglected urban sites. This approach bridges science, art, and activism in capturing the complexity and value of such terrains.

Education: As a teaching site, Planýrka allows students to test planning concepts rooted in animal-aided design, care-based urbanism, and bottom-up interventions. Through direct interaction with the site, students learn to engage with ecological uncertainty and design for coexistence. 360+ LAB organizes public walks in an attempt to popularize the topic and initiate discussions.

Planning Policies: Planýrka is emerging as a platform for negotiating between top-down municipal planning and bottom-up community practices. It opens space for collaborative methods that advocate for vague terrains as legitimate urban typologies—flexible, biodiverse, and socially inclusive.

By focusing on a site often overlooked in planning agendas, 360+ LAB introduces Planýrka as a dynamic example of how urban voids can become meaningful tools for circular, more-than-human strategies. The lab aims to advocate for a new urban ethic—one that embraces ambiguity, listens to multispecies voices, and works toward inclusive and regenerative city-making.

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Faculty of Architecture and Faculty od Fine Arts, Brno University of Technology

360+ LAB

Planýrka as a Platform for More-than-Human Urban Strategies

Planýrka, located in Brno, Czech Republic, is a mosaic of "vague terrains"—neglected, undefined urban spaces shaped by interrupted development and ecosystem succession. Despite their marginal status, these terrains offer critical ecological value and represent a living laboratory for rethinking urban strategies allowing for both human and more-than-human perspectives.

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credits: Daniel Chowaniec, 2024.

RESEARCH: Planýrka provides an in situ environment for monitoring postcultural urban landscapes and nonhuman agencies. One of the key strategies to complement qualitative methods is artistic research, exploring how video art can shape perceptions and narratives around neglected urban sites. This approach bridges science, art, and activism in capturing the complexity and value of such terrains.

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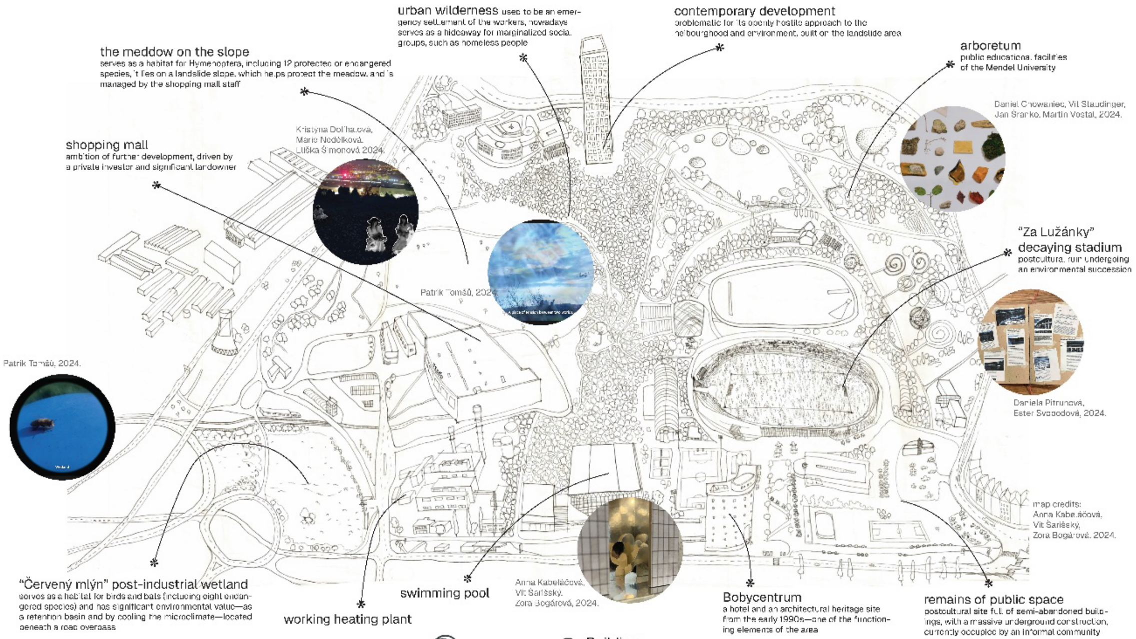
PLANNING POLICIES: Planýrka is emerging as a platform for negotiating between top-down municipal planning and bottom-up community practices. It opens space for collaborative methods that advocate for vague terrains as legitimate urban typologies—flexible, biodiverse, and socially inclusive. By focusing on a site often overlooked in planning agendas, 360+ LAB introduces Planýrka as a dynamic example of how urban "voids" can become meaningful tools for circular, more-than-human strategies. The lab aims to advocate for a new urban ethic—one that embraces ambiguity, listens to multispecies voices, and works toward inclusive and regenerative city-making.


credits: Daniel Chowaniec, 2024.

HYPOTHESIS: Post-cultural landscapes play a crucial role in mitigating the impacts of the climate crisis in urban environments. By providing less-managed spaces, they enable marginalized human groups and non-human species to exercise agency in ways that are restricted within heavily planned and controlled urban settings. Recognizing and integrating these landscapes into urban planning is essential, as they are often undervalued within dominant capitalist planning frameworks due to their perceived lack of conventional "function."

DISCUSSION: At present, we are engaged in advocating for the preservation of the site's key spaces through ongoing dialogue with stakeholders, paying particular attention to the presence of nonhuman species and marginalized human communities. We argue that safeguarding such locations is crucial not only for fostering inclusive social environments but also for contributing to broader strategies of climate crisis mitigation. These spaces hold ecological and cultural significance, positioning them as vital nodes in the pursuit of more just and sustainable futures. Key objectives are mapping the architectural/spatial repurposing of sites by its users/inhabitants, proposing a new typology that would allow the site to not be developed further, and developing a language of moving images to advocate for the site.

RESEARCH QUESTIONS:
How can we articulate the necessity of the post-cultural landscape within the urban structure?
How does multispecies cohabitation influence the transformation of architectural forms?



circular strategies
Building Construction

The Organizational Behavior of Root Systems in Interaction with Surfaces

Demet Öztekinci, Muammer Gümüş, Zehra Delerel, Fitnat Cimşit Koş
Gebze Techincal University, Turkiye

Abstract

This research explores plant root systems as adaptive living systems capable of self-organizing within built environments in response to changing environmental conditions. Root behaviors—such as orientation, spreading, anchoring, retraction, and reconnection—are understood as dynamic processes continuously shaped by external stimuli. Rather than perceiving roots as agents of fixed or predefined geometries, the study conceptualizes them as context-sensitive, spatial, and temporal agents actively participating in the formation of emergent material organizations.

The investigation focuses on how root systems interact with different surface types using seeds from the same plant species. These surfaces include a highly permeable, clay-based substrate and a dense, homogeneous flat plane. Under controlled environmental conditions—stable humidity, diffused lighting, and gravitational influence—the root systems were cultivated in a two-dimensional growth setup. The study tracked the root–surface interaction as an organizational process distributed over time.

The physical traces left by the roots serve not merely as records of growth, but as data structures representing topological transitions, discontinuities, and reconnections. These are interpreted through binary oppositions such as continuity vs. rupture and density vs. sparsity. Variables such as porosity, moisture retention, and material density have been found to influence the overall behavior and orientation of root systems.

This interaction generates a computationally tractable dataset that can be translated into parametric surface strategies, allowing for the design of architectural surfaces that are not static but responsive and co-evolving with their environments. The study thereby proposes an alternative framework for surface design—one that leverages biological data and growth logic to inform digital modeling.

Rather than viewing design as a fixed outcome, this approach reframes it as a living process rooted in adaptability and continuous interaction. By harnessing the generative logic of living systems, architectural production can evolve from static form-making to dynamic material negotiation—enabling surfaces that are reorganizable, temporally informed, and environmentally aware.

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Demet Öztekinci, Muammer Gümüş, Fitnat Cimşit Koş, Zehra Delerel
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Root Systems

Organizational Interactions with Surfaces
Behavioral Traces of Living Matter in Architectural Interfaces

This research focuses on evaluating plant roots as adaptive living systems that, by responding to environmental conditions, demonstrate a self-organizing capacity within the built environment. The behavior of roots includes processes such as orientation, spreading, anchoring, withdrawal, and re-connection, and these dynamics continually evolve through interactions with environmental variables. In this context, roots are not conceived as units producing fixed or predefined geometries; rather, they are regarded as context-sensitive living agents that establish spatial and temporal relations.**[T]**

The study, taking the interaction of these living systems with surfaces as its basis, comparatively examines the behavioral patterns that emerge from the same plant species' seeds when grown on different substrate types for example, a highly permeable, clay-based surface versus a homogeneous, dense **[T]** flat surface.

Methodologically, root systems were cultivated in a two-dimensional arrangement between transparent planes under controlled environmental conditions (constant humidity, diffuse light, gravity). The interaction of roots with the surface has been investigated as an organizational process unfolding **[M]** over time. The traces formed by roots on the surface represent not only the physical behavior of growth but also information structures that embody topological transitions, discontinuities, and reconnections. Here, the surface is not a passive ground, but rather an interactive field that responds to root behaviors and is transformed through their movements. The relationship between root and surface can be read through binary oppositions such as continuity and rupture, density and dispersal. Variables of the surface—such as porosity, water retention capacity, and density—shaped the overall organization of the system by influencing the growth rate and orientation of roots.

The root-surface relationship can thus be understood through these dual **[M]** conditions of continuity/rupture and density/dispersal. Over time, such relationships generate organizational data structures that can be processed **[M]** algorithmically and translated into parametric surface strategies. In this regard, the time-based orientation of root systems and their responses to environmental stimuli are evaluated as sets of variables that can be applied to parametric modeling processes. These biological datasets enable the development of architectural surfaces that can evolve alongside living systems—open to change and responsive to context. **[M]**

This approach draws attention to the potential of systems that can adapt to changing contextual conditions while maintaining organizational relations, in contrast to architecture's conventional tendency to produce fixed and predictable objects. Feeding on the generativity of living systems, this model does not reduce design to physical outcomes alone but reconstructs it through interactions rooted in change, uncertainty, and continuity. Within this framework, surface organizations are conceived not as static structures, but as organizational systems capable of evolving over time, reshaping themselves, and responding to environmental data.

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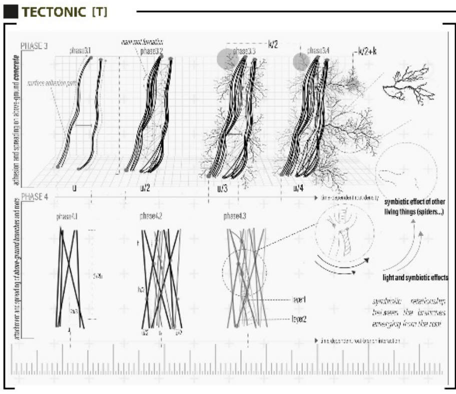
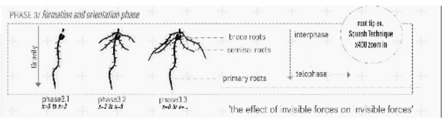
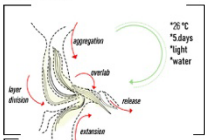
Morphogenesis and emergence (2004–2006). In A. Carpo (Ed.), The digital turn in architecture 1992–2012 (pp. 158–181). Wiley.

TECTONIC [T]

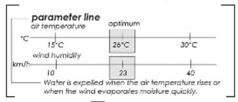


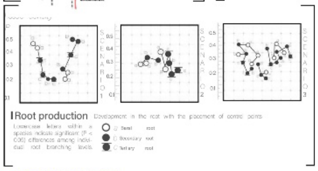


Microscopic



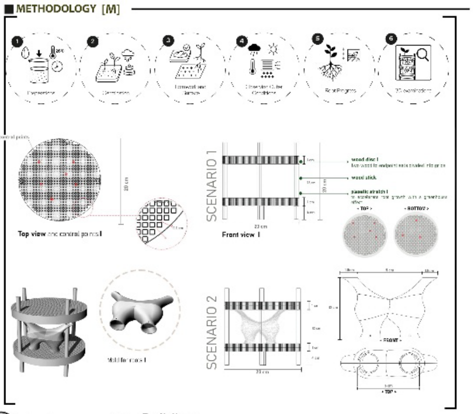
Root growth is modeled through processes such as elongation, layer division, aggregation, overlap, and release. These processes are linked to environmental parameters: optimum root development occurs at 26°C, with humic wind at 23 km/h and a five-day light-water cycle.



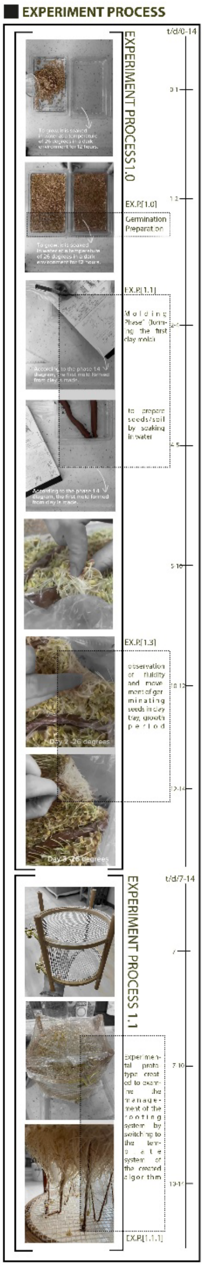


Root systems are modeled through tissue density scenarios at different branching levels (basal, secondary, tertiary). These scenarios are reconfigured via parametric control points, revealing that roots function not only as biological entities but also as spatial, network-based, and generative organizational models.

METHODOLOGY [M]



EXPERIMENT PROCESS



From Chitosan to Chitin: Enabling Structural Biopolymer Transformation During Bioprinting

Marek Holecek, Richard van Nieuwenhoven, Ilse Gebeshuber

Tu wien, Austria

Abstract

In-Process Conversion of Chitosan to Chitin in 3D Bioprinted Structures

Direct 3D printing of chitin is hindered by its poor solubility and processability, making it unsuitable for extrusion-based techniques; however, chitosan—a soluble deacetylated derivative—can be printed effectively, and by initiating reacetylation during the printing process, we approach the fabrication of chitin-based structures in a near-direct manner.. Chitin offers mechanical properties and distinct biodegradation characteristics. Chitin offers superior mechanical properties and distinct biodegradation characteristics, making it highly attractive for biomedical and sustainable material applications. The ability to convert between these polysaccharides opens new possibilities for tailoring scaffold properties for specific tissue engineering applications.

The experimental component focuses on applying established reacetylation chemistry to laboratory-produced 3D bioprinted chitosan structures. Constructs will be treated with acetic anhydride in methanol solutions during the printing process, with systematic optimisation of reaction conditions including concentration, temperature, and treatment duration. Conversion success and structural integrity will be characterised using Scanning Electron Microscopy (SEM) and X-ray Photoelectron Spectroscopy (XPS) to analyse morphological changes and surface chemistry modifications.

Key objectives include optimising conversion protocols, evaluating preservation of microscale features during treatment, comparing mechanical properties before and after conversion, and proposing theoretical frameworks for integrated conversion-printing systems. Expected outcomes include validated protocols for chitosan-to-chitin conversion in 3D printed constructs, comprehensive material characterisation, and theoretical guidelines for future in-situ conversion development.

This interdisciplinary work bridges 3D bioprinting technology with polysaccharide chemistry, potentially enabling programmable scaffold properties for wound healing, tissue regeneration, and controlled drug delivery applications.

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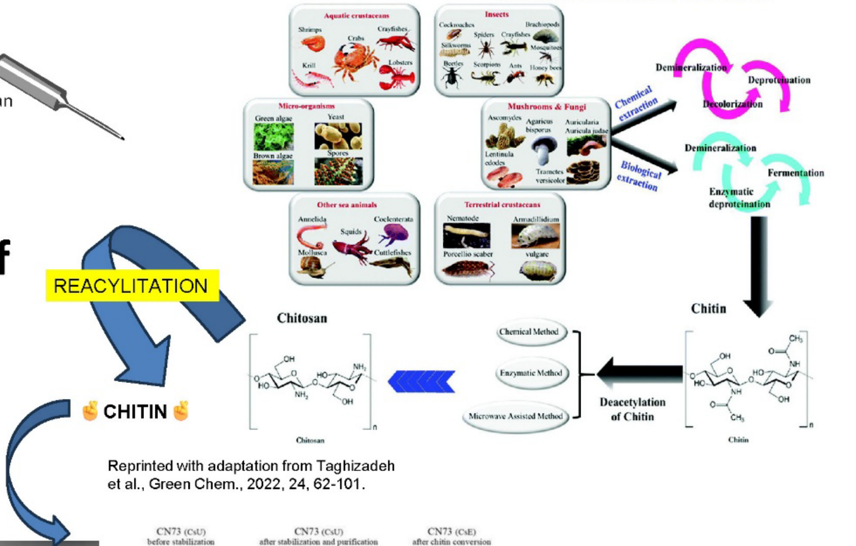
Authors: Marek Holecek, Richard van Nieuwenhoven, Ille C. Gebeshuber,
Organizations: TU Wien

In-Process Conversion of Chitosan to Chitin in 3D Bioprinted Structures



Reprinted with adaptation from Taghizadeh et al., Green Chem., 2022, 24, 62-101.

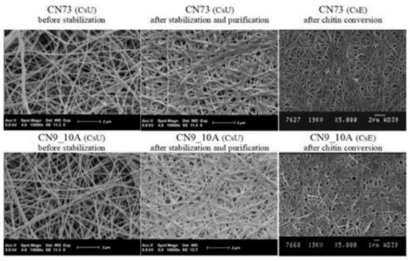
Proposed Methodology for *In-Situ* Conversion During 3D Bioprinting

Chitin vs Chitosan

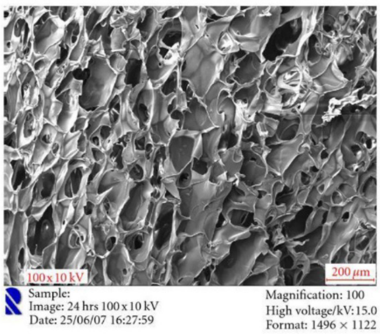
Both are biopolymers derived from the exoskeletons of crustaceans, but they differ in their chemical structure and properties.
Chitin offers superior mechanical properties and distinct biodegradation characteristics, making it highly attractive for biomedical and sustainable material applications.
Chitin, as opposed to chitosan, is of high interest for applications regarding functional surfaces in architecture because of its water-resistant properties.
The ability to convert between these polysaccharides opens new possibilities for tailoring scaffold properties for specific tissue engineering applications.

3D Printing

Direct 3D printing of chitin is hindered by its poor solubility and processability, making it unsuitable for extrusion-based techniques; however, chitosan— a soluble deacetylated derivative— can be printed effectively.



ESEM analysis of electrospun chitosan mats before, after stabilization and after reacetylation. Adapted from Toncheva-Moncheva et al., Polysaccharides, 2021, 2, 271-286.



Electron microscopy of the structure of Chitosan skin regenerating template (SRT) and pore size.
Adapted from Yussof et al., ISRN Mater. Sci., 2011, 2011, 857483

Shrimp shells and crab exoskeletons contain a significant amount chitin. This waste product from the seafood industry thereby becomes one of the main sources of chitin.

Proposed Methods

Objective

To develop an *in-situ* reacetylation method where chitosan converts to chitin during extrusion, as proof-of-concept for integrated 3D bioprinting.

Approach

Direct extrusion into reacetylation bath (via syringe) eliminates post-processing steps and enables real-time conversion.

Expected Outcome

Validated protocol for converting chitosan to chitin during fibre formation, applicable to future 3D printing integration.

Characterization

Conversion success and structural integrity will be characterised using Scanning Electron Microscopy (SEM) and X-ray Photoelectron Spectroscopy (XPS) to analyse morphological changes and surface chemistry modifications.

circular strategies
Building Construction

Peacock Mantis Shrimp,
Photo by William Warby on Unsplash

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Living Surface Morphology; Light Exposure, and Water Effect in Moss Colonization

Berk Girgin[1], Sıla Özdoğan[1], Zeynep Özge Tepe[1], Fitnat Cimşit Koş[1], Seben Aşkın Kütükçü[1], Zehra Delerel[1], Oğuzhan Şenuysal[1], Betül Ozar[2]

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Abstract

This study investigates the impact of surface topography, light exposure, and water retention on the colonization of surfaces in the urban environment by moss, particularly on concrete. With emphasis on Brachythecium rutabulum, The resilient and living presence of moss in urban environments holds potential as a component of bio-integrated design. For this reason, the article explores the optimal environmental conditions for this moss species both in pore and crack formations.

The mosses show two dominant life stages: protonema and gametophyte (Glime, 2007). The gametophyte stage produces spores that are dispersed by animals and wind. Once the spores reach the moisture-retaining pores, they enter the protonema stage and start the growth cycle. Surface textures formed by wind and water weathering form capillary porosity, which are the necessary spaces for spores and moisture retention (Hall & Hoff, 2002).

In addition, the research also examined how solar exposure, as well as surface form, affected the well-being of moss. Parametric models of different pavement cracks deep and shaded, versus flat and exposed were created and subjected to real sunlight. It was discovered that moss in deeper, set-back cracks exhibited higher levels of moisture retention and more compact pigmentation, whereas those in exposed conditions suffered chlorophyll loss and desiccation from overexposure to solar radiation.

In order to replicate such conditions, digital models were prepared through re-animation and collage methods, mimicking pore formations and their behaviors in concrete surfaces. This new morphology was 3D-printed and moss was placed on the pores and cracks.Hybridisation and growth were observed in the greenhouse environment. Moss samples exposed to the models developed well from protonema to gametophyte, validating the conduciveness of designed surfaces to moss development.

These observations are consistent with the existing body of our research on bio-receptive materials (Mustafa et al., 2023), demonstrating that moss ecosystems can be supported in architecture and urban design through passive shading, capillary porosity, and surface microtopography as being of paramount importance in promoting moss ecosystems on architectural surfaces. The study reveals that surface design can mediate urban biological colonization and contribute to the development of bio-integration strategies in architecture.

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Berk Girgin[1], Sıla Özdoğan[1], Zeynep Özge Tepe[1], Fitnat Cimşit Koş[1], Seben Aşkın Kütükçü[1], Zehra Delerel[1], Oğuzhan Şenuysal[1], Betül Ozar[2]
[1]Gebze Technical University, Responsive Ground Research Lab. Turkiye; [2]Işık University, Turkiye

Berk Girgin
Sıla Özdoğan

Living Surface Morphology; Light Exposure, and Water Effect in Moss Colonization

Abstract

This study investigates the impact of surface topography, light exposure, and water retention on the colonization of surfaces in the urban environment by moss, particularly on concrete. With emphasis on Brachythecium rutabulum, The resilient and living presence of moss in urban environments holds potential as a component of bio-integrated design. For this reason, the article explores the optimal environmental conditions for this moss species both in pore and crack formations.

The mosses show two dominant life stages: protonema and gametophyte (Glime, 2007). The gametophyte stage produces spores that are dispersed by animals and wind. Once the spores reach the moisture-retaining pores, they enter the protonema stage and start the growth cycle. Surface textures formed by wind and water weathering form capillary porosity, which are the necessary spaces for spores and moisture retention (Hall & Hoff, 2002).

In addition, the research also examined how solar exposure, as well as surface form, affected the well-being of moss. Parametric models of different pavement cracks deep and shaded, versus flat and exposed were created and subjected to real sunlight. It was discovered that moss in deeper, set-back cracks exhibited higher levels of moisture retention and more compact pigmentation, whereas those in exposed conditions suffered chlorophyll loss and desiccation from overexposure to solar radiation.

In order to replicate such conditions, digital models were prepared through re-animation and collage methods, mimicking pore formations and their behaviors in concrete surfaces. This new morphology was 3D-printed and moss was placed on the pores and cracks.Hybridisation and growth were observed in the greenhouse environment. Moss samples exposed to the models developed well from protonema to gametophyte, validating the conduciveness of designed surfaces to moss development.

These observations are consistent with the existing body of our research on bio-receptive materials (Mustafa et al., 2023), demonstrating that moss ecosystems can be supported in architecture and urban design through passive shading, capillary porosity, and surface microtopography as being of paramount importance in promoting moss ecosystems on architectural surfaces. The study reveals that surface design can mediate urban biological colonization and contribute to the development of bio-integration strategies in architecture.

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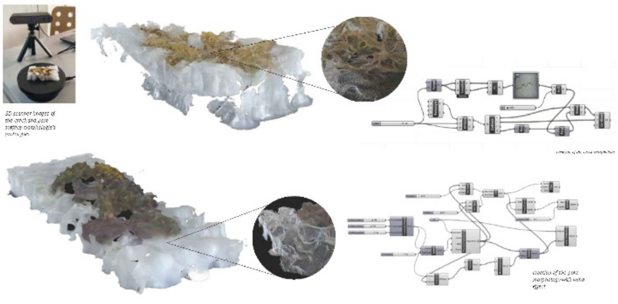

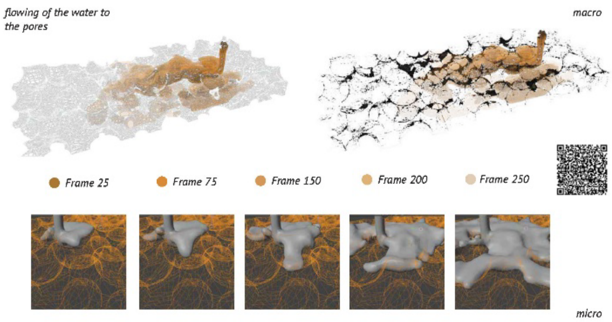

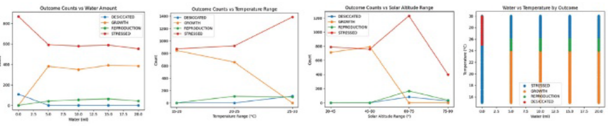

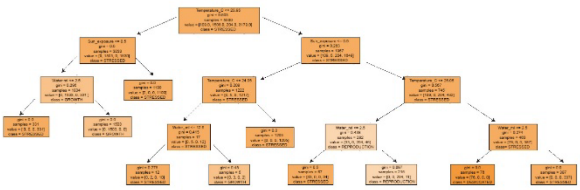

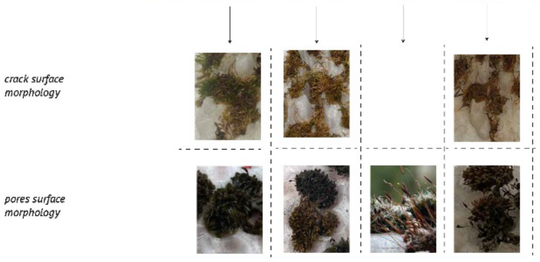

Decoding Ivy-Induced Feedback Loops: Modeling Cumulative Biological Impacts and Morphological Adaptation

Ataberk Kahraman[1], Fitnat Cimşit Koş[1], Zehra Delerel[1], Özgür Kavurmacıoğlu[1], Betül Ozar[2], Yusuf Çiftci[1]

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Abstract

Ivy plants exhibit a distinctive growth pattern that merges biological adaptation with structural interaction. Beginning their life cycle in soil, they climb vertically when encountering suitable surfaces such as walls or trees, forming an evolving and dynamic relationship with architectural elements. This study introduces a computational model that investigates ivy's growth behavior and water absorption dynamics, aiming to understand their implications on material performance.

Utilizing Python scripting in Rhino, the research develops digital simulations that replicate ivy's exploratory movement and interaction with porous building components. Curves and volumetric forms visualize the organic expansion of the plant, while the model shifts its focus from representation toward performance-oriented analysis of material transformation over time.

As the ivy establishes contact with porous substrates like mortar, moisture is gradually extracted, disrupting the internal equilibrium of the material. This leads to a drying process, the emergence of micro-fractures, and a reduction in structural cohesion. Such transformations indicate how material surfaces begin to respond in a tissue-like manner—modulated by continuous biological input and environmental exposure.

Simultaneously, the redistribution of water within the structure generates spatial hydrological gradients. These gradients influence the direction and density of biological colonization, with the architectural surface becoming an active participant in regulating flows of matter and energy. Rather than functioning solely as inert host, it evolves into a responsive mediator shaped by living processes.

Over time, the accumulation of micro-damage triggers adaptive responses inspired by regenerative biology. The model speculates how material systems might develop self-regulating or healing capacities in response to stress. Through feedback-driven behaviors, architectural components begin to mirror the regenerative logic observed in living tissues—enabling local restoration and performance recovery.

These intertwined mechanisms of biological interaction, hydrological redistribution, and material adaptation offer new insights into resilient design strategies. Rather than resisting change, materials are envisioned as dynamically evolving systems, continuously shaped by their environment. Future phases of the research will integrate high-resolution datasets and physical testing to validate the computational predictions and explore practical applications of bio-integrated material systems.

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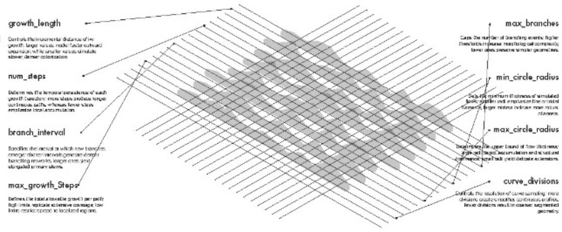
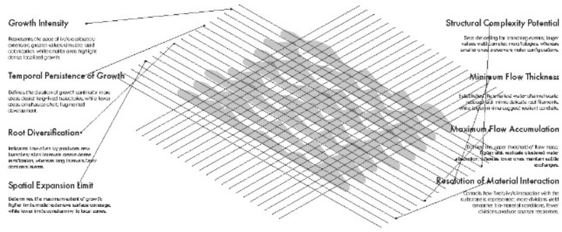
Decoding Ivy-Induced Feedback Loops:

Modeling Cumulative Biological Impacts and Morphological Adaptation





Research

Ivy plants exhibit a distinctive growth pattern that merges biological adaptation with structural interaction. Beginning their life cycle in soil, they climb vertically when encountering suitable surfaces such as walls or trees, forming an evolving and dynamic relationship with architectural elements. This study introduces a computational model that investigates ivy's growth behavior and water absorption dynamics, aiming to understand their implications on material performance.

Methodology

Utilizing Python scripting in Rhino, the research develops digital simulations that replicate ivy's exploratory movement and interaction with porous building components. Curves and volumetric forms visualize the organic expansion of the plant, while the model shifts its focus from representation toward performance-oriented analysis of material transformation over time.

As the ivy establishes contact with porous substrates like mortar, moisture is gradually extracted, disrupting the internal equilibrium of the material. This leads to a drying process, the emergence of micro-fractures, and a reduction in structural cohesion. Simultaneously, the redistribution of water within the structure generates spatial hydrological gradients. These gradients influence the direction and density of biological colonization, with the architectural surface becoming an active participant in regulating flows of matter and energy.

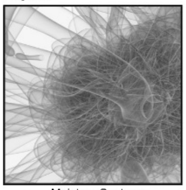
Findings

Rather than functioning solely as an inert host, the architectural surface evolves into a responsive mediator shaped by living processes. Over time, the accumulation of micro-damage triggers adaptive responses inspired by regenerative biology. The model speculates how material systems might develop self-regulating or healing capacities in response to stress.

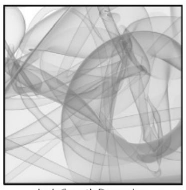
Through feedback-driven behaviors, architectural components begin to mirror the regenerative logic observed in living tissues—enabling local restoration and performance recovery. These intertwined mechanisms of biological interaction, hydrological redistribution, and material adaptation offer new insights into resilient design strategies. Rather than resisting change, materials are envisioned as dynamically evolving systems, continuously shaped by their environment.

The research process is still ongoing, and future phases will integrate high-resolution datasets and physical testing to validate the computational predictions and explore practical applications of bio-integrated material systems.

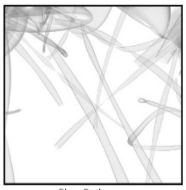
Layers



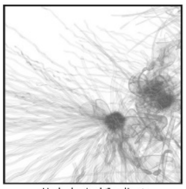
Moisture Capture
Water is absorbed into the mortar's micro-cavities, creating local reservoirs that initiate material transformation.



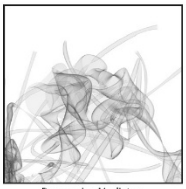
Ivy's Growth Dynamics
Ivy explores its environment through adaptive climbing behavior, weaving organic trajectories across architectural surfaces.



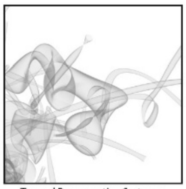
Flow Pathways
Extracted water redistributes along hydrological gradients, guiding the direction and density of further colonization.



Hydrological Gradient
Large-scale redistribution of moisture generates environmental flows that regulate biological activity across surfaces.

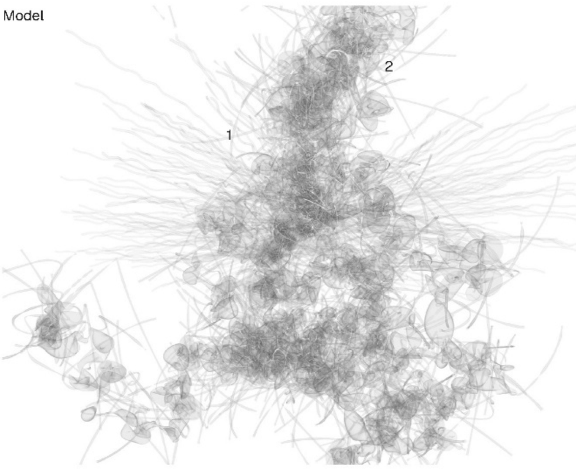


Responsive Mediator
Instead of remaining passive, the architectural surface evolves into an active interface, shaping exchanges of matter and energy.



Toward Regenerative Systems
Accumulated stress and micro-damage trigger adaptive, tissue-like responses, envisioning materials as self-regulating, resilient systems.

Model



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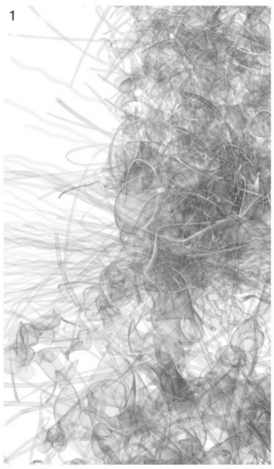

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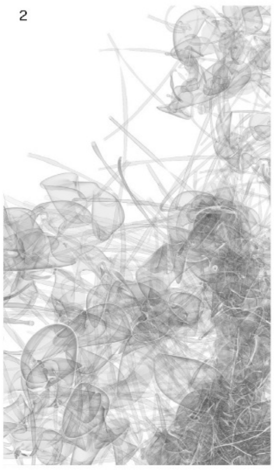

From Nanostructure to Function: Hierarchical Functional Structures in Chitin and Keratin

Julia Freigassner, Richard W. van Nieuwenhoven, Ille C. Gebeshuber

Technische Universität Wien, Austria

Abstract

Nature offers a wealth of inspiration for architecture and engineering, with many biological materials and structures serving as models for efficient, multifunctional designs, even in their unaltered forms. Among these, the natural biopolymers chitin and keratin stand out for their potential in sustainable material innovation and biomimetic construction. Their hierarchical organization, chemical structure, biodegradability, and inherent functionalities make them compelling alternatives to synthetic materials.

Chitin, a polysaccharide composed of β-(1→4)-linked N-acetylglucosamine units, forms crystalline, hydrogen-bonded fibril networks that provide both flexibility and rigidity. Found in marine organisms, arthropod exoskeletons, and fungal cell walls, it is primarily sourced from the food industry, including waste such as shrimp shells and squid pens. Chitin and its derivative, chitosan, offer mechanical stability, bactericidal properties, passive radiative cooling (e.g., inspired by the Saharan silver ant), pharmaceutical applications such as drug delivery, wound healing, and tissue engineering and stunning structural coloration, an effect demonstrated by the chitosan film in Figure 1.

Keratin, a versatile cysteine-rich fibrous protein found in feathers, wool, and hooves, features a coiled-coil architecture and multiscale layering, comprising both crystalline and amorphous regions, which enable mechanical resilience, lightweight design, and structural integrity. It offers exceptional thermal insulation and crack redirection mechanisms, making it a valuable model for impact-resistant and earthquake-adaptive constructions. Furthermore, its bactericidal, self-cleaning surface properties, such as those found in gecko skin, hold promise for hygienic, low-maintenance architectural components.

By reclaiming waste streams from the food and textile industries, such as shrimp shells, poultry feathers and wool, chitin and keratin exemplify how discarded biological matter can be transformed into high-performance, multifunctional material systems. Their functional properties could enable a wide range of applications: passive radiative cooling, non-toxic structural colouration as an alternative to potentially harmful dyes and coatings, stress- and energy-absorbing architectural systems, reversible adhesive and bactericidal surfaces, biodegradable packaging, as well as thermal insulation and water-repellent elements in building structures. These biologically informed materials support circular design approaches that integrate durability, adaptability, and environmental care, pointing towards a self-sustaining, ecologically integrated architecture.

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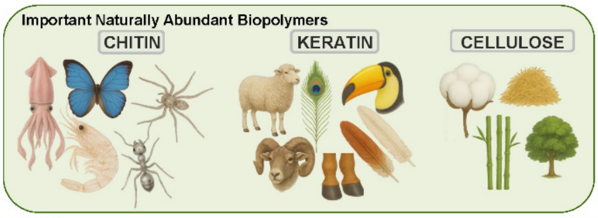
Institute of Applied Physics, TU Wien, Austria

From Nanostructure to Function

Hierarchical Functional Structures in Chitin and Keratin

Important Naturally Abundant Biopolymers

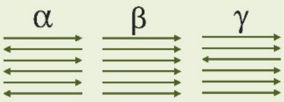


From Waste to Value

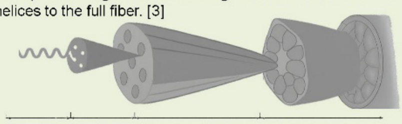
The food industry leaves behind enormous streams of feathers, wool, hooves, and shrimp shells. Too often, these rich sources of chitin and keratin are simply discarded. By reclaiming them, **waste becomes a resource**: high-performance materials that re-enter circular cycles and **replace synthetics**. What was once thrown away can instead form the foundation of a sustainable, regenerative future - demonstrating how biological matter can be cultivated into lasting value. [1]

Unique Chemical Structures

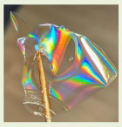
CHITIN
Chitin is a natural polysaccharide composed of N-acetylglucosamine units linked by β-(1→4) glycosidic bonds, forming polymer chains. These chains assemble into three crystalline polymorphs: α, β, and γ. Strong intra-sheet hydrogen bonding provides stability and rigidity. Bundled into crystalline microfibrils, these chains form fibers and networks that confer strength and flexibility to biological structures such as arthropod exoskeletons and fungal cell walls. [2]

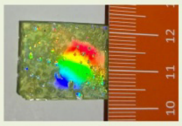


KERATIN
Keratin is a fibrous protein occurring as α-keratin in mammals (hair, wool, horns) and β-keratin in birds and reptiles (feathers, scales). Its molecules form α-helices or β-sheets stabilized by hydrogen bonds, assembling into protofilaments, intermediate filaments and macroscopic structures such as hooves or feathers. Disulfide bonds between cysteine residues provide strength and flexibility, with hair as an example showing a hierarchical organization from nanoscale helices to the full fiber. [3]



Properties	Chitin	Keratin
Lightweight Structures	✓	✓
Structural Colour Effects	✓	✓
Thermal Insulation	✗	✓
Passive Radiative Cooling	✓	✗
Reversible Adhesion	✗	✓
High Fracture Resistance	✓	✓
High stiffness/rigidity	✓	✓


Chitosan film showing structural colouration



Keratin sheet showing structural colouration

Outstanding Properties

CHITIN
Chitin is **lightweight, strong, and flexible**, combining **rigidity** with **adaptability** across scales. Its natural fibril networks provide **high mechanical stability** while maintaining low density. Chitin surfaces can exhibit **antibacterial** and **antifungal** activity, contributing to hygienic and durable structures. In nature, it is responsible for striking **structural coloration**, as seen in butterfly wings, and it supports **passive radiative cooling**, as in the Saharan silver ant. Beyond these optical and thermal properties, chitin is **biocompatible and biodegradable,** making it a versatile foundation for sustainable, multifunctional materials. These qualities highlight chitin's potential to replace synthetic materials in circular design strategies. [4]

KERATIN
Keratin is one of nature's most **resilient** structural proteins, uniting **strength** with **flexibility**. Its hierarchical organization produces **lightweight** but durable materials capable of **absorbing stress** and **redirecting cracks**, as seen in hooves and claws. Keratin offers excellent **thermal insulation** in feathers and fur, while its surfaces often exhibit **hydrophobic** and **self-cleaning** behaviour. Beyond these protective roles, keratin structures can enable **reversible adhesion** and striking, non-fading **structural colour**, exemplified in bird feathers and reptile scales. **Biocompatible** and **biodegradable**, keratin represents a renewable resource for multifunctional, adaptive, and sustainable material systems.[4]

Possible Architectural Applications

- Passive radiative cooling for façades and roofs (inspired by the Saharan Silver Ant).
- Biodegradable colouration with non-toxic structural colour (no synthetic pigments).
- Shock-absorbing and crack-redirecting elements for earthquake-adaptive structures.
- Thermal insulation and water-repellent layers in walls, façades, and roofs.
- Hygienic, self-cleaning surfaces for hospitals, kitchens, and public buildings.
- Lightweight composite panels with high strength-to-weight ratio.
- Reversible adhesive interfaces for modular and reconfigurable building systems.
- Acoustic insulation panels using keratin fibers (sound-absorbers).
- Energy-efficient façade systems combining thermal insulation and passive cooling.
- Bio-integrated materials that can degrade and return safely to the environment.
- Anti-icing façades and roof surfaces inspired by penguin feathers reduced ice formation in winter - increased safety.

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Julia Freigassner
Richard W. van Nieuwenhoven
Ille C. Gebeshuber

circular strategies
Building Construction

Trans-Material Dialogues: Haptic Tectonic Inquiries Through Bio-Based Experimentation

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Gebze Technical University, Turkiye

Abstract

Contemporary architecture, with the proliferation of digital tools and the observation of natural processes, seeks to redefine itself in terms of reciprocity and co-evolution, moving beyond mere representation in its relationship with vitality. This study, developed as part of ongoing doctoral research, proposes a trans-material and trans-digital design methodology for architectural production. Experiments involving local organic waste—specifically coffee grounds—along with mycelium, lichen, and plant seeds were conducted under variable air flow, humidity, and light conditions. The processes of living matter adhering to surfaces, spreading, self-organising, decomposing, and regenerating were documented (Figure 1). These observations reveal the performative, adaptive and haptic properties of biohybrid materials, developing an intuitive practice of "material reading". While mycelium hyphae colonised and whitened the coffee surface, lichens preferred to attach themselves to porous areas; some seeds germinated faster in moist, dark areas (Figure 2). As architecture's "smallest structural decision", it can be noted that the material itself becomes a symbiotic ecosystem. At the mesoscopic scale, the relationship between the behaviour of the materials obtained and the production techniques can be referenced in modules and prototypes that establish inter-scale networks. In the early stages, the elasticity of the biomaterial allows for the manipulation of form. Relationships that are not yet structural but are based on environmental performance, such as facade proposals, functional panels, and urban fragments, can transform into design components where the material is no longer alone but is related to climate, vitality, and ecological context. Here, scale is not merely a physical magnitude; it is considered the "permeable carrier of living relationships" established between environments such as air, soil, and water. These "(a)scalar tectonics" between material, environment, and perception aim to establish a multi-layered interaction. These non-linear interactions relate to the uncertainty of nature; they trace the path of an unpredictable, evolving, decaying, sensitive, haptic, living, co-produced ‘‘architecture of networks of relationships’’.

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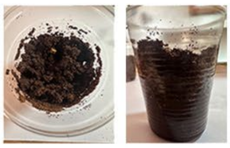
November 20–21, 2025
University of Applied Arts Vienna, Auditorium,
Vordere Zollamtsstraße 7, 1030 Vienna

Dilara Yiğit, Fitnat Cimşit Koş
Gebze Technical University, Responsive Ground Research Lab.

Trans-Material Dialogues:
Haptic Tectonic Inquiries Through Bio-Based Experimentation

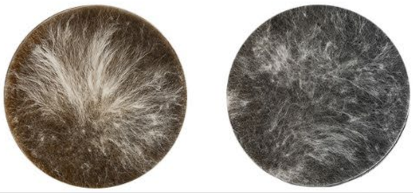


Contemporary architecture, with the proliferation of digital tools and the observation of natural processes, seeks to redefine itself in terms of reciprocity and co-evolution, moving beyond mere representation in its relationship with vitality. This study, developed as part of ongoing doctoral research, proposes a trans-material and trans-digital design methodology for architectural production. Experiments involving local organic waste—specifically coffee grounds—along with mycelium, lichen, and plant seeds were conducted under variable air flow, humidity, and light conditions. The processes of living matter adhering to surfaces, spreading, self-organising, decomposing, and regenerating were documented (Figure 1).

fig. 1: experimental processes.

These observations reveal the performative, adaptive and haptic properties of biohybrid materials, developing an intuitive practice of "material reading". While mycelium hyphae colonised and whitened the coffee surface, lichens preferred to attach themselves to porous areas; some seeds germinated faster in moist, dark areas (Figure 2). As architecture's **"smallest structural decision"**, it can be noted that the material itself becomes a symbiotic ecosystem. At the mesoscopic scale, the relationship between the behaviour of the materials obtained and the production techniques can be referenced in modules and prototypes that establish inter-scale networks. In the early stages, the elasticity of the biomaterial allows for the manipulation of form. Relationships that are not yet structural but are based on environmental performance, such as facade proposals, functional panels, and urban fragments, can transform into design components where the material is no longer alone but is related to climate, vitality, and ecological context. Here, scale is not merely a physical magnitude; it is considered the **"permeable carrier of living relationships"** established between environments such as air, soil, and water. These **"(a)scalar tectonics"** between material, environment, and perception aim to establish a multi-layered interaction. These non-linear interactions relate to the uncertainty of nature; they trace the path of an unpredictable, evolving, decaying, sensitive, **haptic,** living, co-produced **"architecture of networks of relationships"** (Yiğit, in prep.).

Keywords: Biomaterial, Living Architecture, Haptic Tectonics, Symbiosis, Interscalar Sensibility



the spread of mycelium into coffee particles and the reduction of coffee visibility.

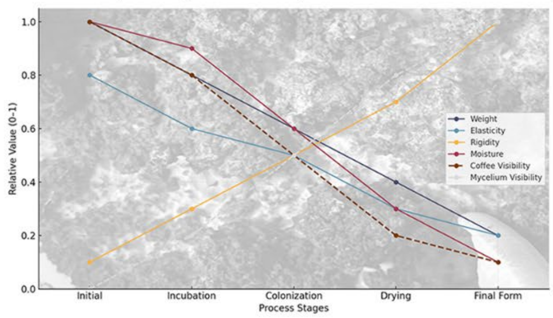


fig 2: coffee + mycelium process - material & surface change.

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circular strategies

Building Construction

The Confluence of Parametric Design and Mycelium Fabrication

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Abstract

The future of architectural design is deeply rooted in sustainability, emphasizing the importance of material selection in creating robust and efficient buildings. Numerous case studies highlight how the use of renewable resources and energy-efficient materials showcases the transformative impact of sustainable practices in the industry. The growing potential of mycelium as a sustainable building material creates new opportunities for architectural design and construction. Furthermore, digital fabrication leads the way in merging the digital and material aspects of architecture. This transformation encompasses key elements such as dynamic design processes, the fusion of construction and programming within the design process, and control over manufacturing. Digital fabrication not only integrates digital and material facets but also redefines the role of architects, allowing them to craft more intricate, responsive, and informed architectural expressions.

This research delves into the confluence of digital and physical processes in creating mycelium-based structural modules, concentrating on the synergy between computational design tools and material biotechnology. By leveraging parametric design tools, the study aims to improve the structural properties of mycelium-based composites and adapt them for the creation of architectural component typologies. The physical production process melds digital fabrication methods with the biological growth of mycelium, where the material is cultivated in molds and formed to meet custom design criteria.

The study presents a design-and-make case study that combines parametric modeling, digital fabrication techniques, and the biological growth of mycelium to create custom, environmentally responsive structural elements. Specifically, the case study outlines the design and fabrication process of mycelium-based composite module prototypes for a temporary architectural installation. It emphasizes the iterative design process, to achieve the desired structural integrity. Additionally, this research addresses the challenges of blending digital precision with the inherent unpredictability of biological growth, highlighting the need for a hybrid approach to mycelium-based material fabrication that bridges digital design and biological processes. Ultimately, this research aims to promote a digital fabrication workflow and ecological solution for creating structural elements, within an open-source and community-driven framework.

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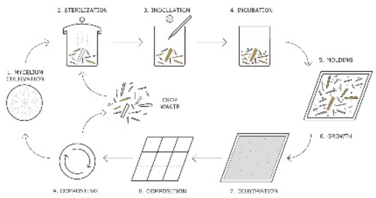
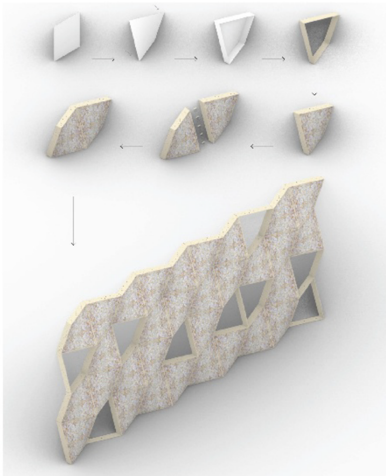
The Confluence of Parametric Design and Mycelium Fabrication



Mycelium fabrication process diagram, from fungal strain and crop waste, to mycelium-based composite (MBC) material, and to spatial structural components.


Mycelium substrate, from shredded straw, to mycelium inoculation, and MBC.


First scenario's model diagram: Linear tessellation of a hyperbolic paraboloid mycelium panel module of the self standing partition wall installation.


Detail of the plywood frame of the hyperbolic paraboloid panel, before and after the mycelium aggregation with the plywood.

Abstract

Introduction

The future of architectural design is increasingly oriented toward sustainability, emphasizing the importance of material selection in creating robust and efficient buildings. Numerous case studies highlight how the use of renewable resources and energy-efficient materials demonstrate the transformative impact of sustainable practices in the industry (Kibert 2016). The growing potential of mycelium as a sustainable building material creates new opportunities for architectural design and construction (Ghazvinian and Gursoy 2022), (Attias et al. 2020). Furthermore, digital fabrication leads the way in merging the digital and material aspects of architecture. This transformation encompasses key elements such as dynamic design processes, the fusion of construction and programming within the design process, and control over manufacturing (Gramazio and Kohler 2008). Digital fabrication not only integrates digital and material facets but also redefines the role of architects, allowing them to craft more intricate, responsive, and informed architectural expressions.

Methodology

This research delves into the confluence of digital and physical processes in creating mycelium-based structural modules (Özdemir et al. 2022), concentrating on the synergy between computational design tools and material biotechnology (Bitting et al. 2022). The two factors that enrich our toolbox for the creation of cohesive, plywood-framed (Almpani-Lekka et al. 2021), self standing structural modules made by mycelium based composites (MBCs) are parametric design and mycelium material customization. On the one hand, we have the capability to generate design solutions that can be parametrically controlled in terms of their structural performance and aesthetic characteristics. The two main parameters within our design process are: the shape of the module, and the overall shape of the spatial installation. On the other hand, the MBC's properties that are affecting its structural integrity are dependent on the fungal strain and substrate type, as well as on the growth conditions and post-treatment of the material. The physical production process melds digital fabrication methods with the biological growth of mycelium (Elsacker et al. 2019), where the material is cultivated in molds and shaped (Kourtidis Vlachogiannis et al. 2024). More specifically, the plywood frames of the prototypes are digitally fabricated by laser cutter, hemp threads are weaved to bind the frame, which is filled by mycelium substrate that grows and aggregates to the frame.

Result

The study presents a design-and-make case study that combines parametric modeling, digital fabrication techniques, and the biological growth of mycelium to create custom structural elements. Specifically, the case study outlines the design and fabrication process of plywood-framed mycelium-based composite module prototypes for a temporary architectural installation. It emphasizes the iterative design process to achieve the desired structural integrity. Additionally, this research addresses the challenges of blending digital precision with the inherent unpredictability of biological growth, highlighting the need for a hybrid approach to mycelium based material fabrication that bridges digital design and biological processes.

Conclusion

The structural durability of mycelium-based composites requires further testing. Physical simulations would be applied to test the mechanical properties of the material samples. Ultimately, this research aims to promote a digital fabrication workflow and ecological solution for creating structural elements, within an open-source (Top Lab 2019) and community-driven framework.

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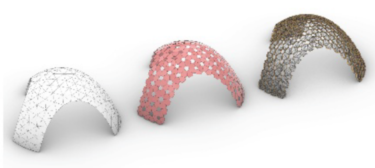
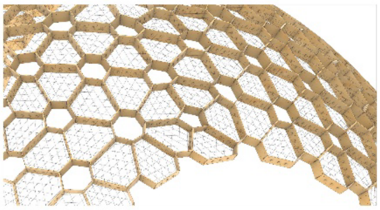
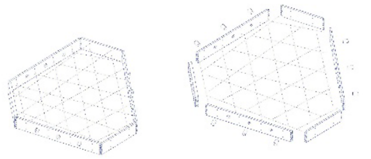
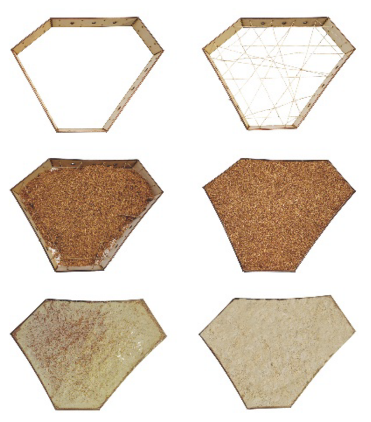

Second scenario: Doubly curved vaulted structure, necessitating the design of variable components. A solver that generated non-linear tessellations of planar hexagons was developed, ensuring planarity by inscribing each component within a triangle.


Planar hexagon panel frames' tessellation. Beaver for Grasshopper (Beaver, 2024) was used to analyze the structural behavior of wooden connectors.


Hexagonal panel module and its components: plywood frame, hemp thread, and wood dowels.


The mycelium prototype framed panel. The plywood mold was bound with hemp threads, filled with mycelium substrate, and was let to grow for one week within an incubation bag. During this period, the mycelium grew and aggregated to the plywood frame and the hemp thread.

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