LIVING TEXTILE ARCHITECTURES

Towards Multi-Species, Multi-Scale Interaction

ABOUT THE SYMPOSIUM

What does it mean to design for multi-species interactions? How can biology transform our understanding of scale in textiles and architecture? How does technology intersect with the living and the non-living in biohybrid materials and systems for construction?

Since the formation of the ArcInTex Network, the intersection of textiles, architecture and interaction design has been transformed by biology. Biodesign has emerged as an important discipline that addresses the potential to integrate living systems into design to create alternative, sustainable outcomes. The novel hybrid methodologies that are emerging bring scientists and designers together with technologists to explore strategies to cultivate and grow new materials that have the potential to radically reduce the impact of our industries. Biological systems offer a model of low energy and circular production, but how can we best create, build and collaborate with nature in the pursuit of regenerative design? How can we design with microbial communities using textiles processes to generate healthy microbiomes for the built environment?

And how do we remain critically aware of the implications of the technologies that we are creating?This ARCINTEX symposium, hosted by the Hub for Biotechnology in the Built Environment will reflect on the interactions between textiles, interaction design and architecture through the lens of biology to reveal the ideas, networks and new materiality emerging within our community.

This three-day event will bring the ArcInTex community together in Newcastle to share ideas and discuss new and emerging research. The event will comprise a two-day single-track symposium, keynote discussions, a dedicated PhD forum, and a showcase event to exhibit artefacts and design work during the symposium.

Dates:
12 – 14th October 2022.

Hub for Biotechnology in the Built Environment · Newcastle University · Northumbria University Newcastle · UKRI Research England · ArcInTex Network

11.20 – 12.40

Session 1: Responsive Bio-textile Hybrids

(Single Track Presentations)

Angela Sherry
Hub for Biotechnology in the Built Environment (HBBE)

Fibre Highways: translocation of the microbiome on textiles for multiple applications

Angela Sherry1, Jane Scott2

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Research into the way microbes move within our living spaces and interact with materials and textiles within our homes is essential, and gaining traction as we begin to cohabit more readily with 'living materials'. Fibre Highways is a proof-of-concept study where we explored microbial interactions with textiles by expanding upon previous research into bacterial motility on fungal highways. The study brought together cross-disciplinary expertise in environmental microbiology with materials and textile science to demonstrate textile fibres providing scaffolds and highways for microbial translocation.

From a design perspective the studio was extended into the lab to develop multi-kingdom ecosystems that integrated textiles with microbial communities; using knitting as a tool for conceptual thinking, a microbial transport system and an active agent in the application of bioremediation. The intention of the project was to demonstrate how a symbiotic relationship could develop between knitted fabrics and microorganisms, and to deploy these responsive living textiles to address significant environmental challenges.

Scale is a preoccupation of every knit designer because fabric properties evolve between the levels of the fibre, the yarn and the knit structure. This offers multiple opportunities for functionalisation. At a micro scale, fibre morphology informed the design of fabric for microbial habitation. At a macro scale fabric structure was engineered for variable liquid absorption rates and environmentally responsive shape change. Interactions on fibres across decreasing microbial scales (fungi, bacteria, bacterial spores) was also considered.

Fibre Highways moves towards transforming our understanding of responsive bio-textile hybrids, generating the fundamental science and design perspective necessary to develop biotechnologies required for real world applications.

Emily Birch
Hub for Biotechnology in the Built Environment (HBBE), School of Architecture, Planning and Landscape, Newcastle University

Co-authors: Martyn Dade-Robertson, Ben Bridgens and Meng Zhang

Biodynamic Architectures Harnessing moisture sensitive bacterial spores into responsive, hybrid, living smart materials

There is an incredible tenacity and resilience within the natural world to adapt to changes in the immediate environment. Evolution has refined 'form to follow function' so elegantly that perceivably inert structures such as the pinecone can respond effortlessly to environmental changes. Their unique tissue morphology engineers the motion required for seed dispersal even after death. If we could utilize such systems within architectural design, our reliance upon mechanical and fossil-fuelled systems to maintain our internal environments could finally be made redundant. The urgency for such solutions has been growing in response to the climate crisis and depletion of finite resources which has propelled the development of smart materials to the forefront of scientific research (Koyaz, 2018; Lendlein et al., 2019). Can we develop living smart materials which replicate and or utilize natures' adaptability for applications within our built environment?

There is a class of materials which respond to environmental humidity which are called hygromorphs; the pinecone mentioned earlier is a member of this class. These materials typically swell in humid conditions and shrink in dry environments and do so without the need for any energy input; it is a completely passive process. A common soil bacterium (Bacillus subtilis) develops robust, desiccated spores in hostile environments. By utilising the spores' natural hygromorphic properties within a latex bilayer structure we can harness the simple expansion and contraction into a directional response. 'Active Origami' explored this potential, developing fabrication methodologies, refinement of the bacterial culture protocols and achieving simple programmability (Birch et al., 2021). Our current research, 'Biodynamic Architectures' furthers this emerging material pallet of responses and programmability, leading to complex, refined deformations with potential applications in architecture.

By utilising a multidisciplinary methodology, a synergy between biology and material design has been harnessed to enhance bacterial collaboration to produce controllable shape change in response to changes in relative humidity. Extensive exploration through iterative design has allowed investigation of multiple variables such as inert material type, thickness and resistance patterns, spore state, actuator shape and size, spore adhesion and deposition methodologies to create a comprehensive B. subtilis spore and latex actuator response pallet. Aggregation of responses by integration of specific actuator components from this pallet within a matrix allows formation of apertures with controlled opening rates, magnitudes and response range to specific RH%. This biodynamically active matrix allows us to investigate how these individually small motions can contribute to a larger combined function, and toward the architectural scale.

Experimental results from these matrix aggregations highlight how the comprehensive response pallet can inform production of bespoke, responsive architectures where the functional outcome can be pre-described and programmed. Ongoing research suggests that we are now in a position where a desired function can be conceptualised, designed for, bio-fabricated, and created to produce a desired open area (%) at a desired relative humidity. Through computer simulation we can now begin to predict how these Biodynamic Architectures could passively regulate air flow and humidity exchange within our built environments.

Mangesh Kurund
Bio-Integrated design (Bio-ID), The Bartlett School of Architecture, UCL

Co-authors: Brenda Parker, Anete Salmane, Alexandra Lacatusu and Marcos Cruz.

Bio Chroma hydrogel composite plasters: Substrate to induce bio coloration on algal growth, for architectural surface application.

External building surfaces are constantly exposed to environmental factors that favour the growth of mosses, lichens, and algae. Bioreceptive design develops building materials or surfaces that can naturally favour biological growth. Algae have been used in bioreceptive design projects to allow for carbon sequestration and pigmentation. As photosynthetic eukaryotes, algae use sunlight to conduct photosynthesis to produce oxygen but also salts and heavy metals as additional nutrition sources, which results in sequestration of carbon and pigmentation, respectively. The immobilisation of algae for architectural applications has been performed up to now by using sodium alginate hydrogel as an encapsulating matrix. The low mechanical strength, non-uniform crosslinking and dehydration dynamics of hydrogel encapsulation reduces the cell viability of algae. Factors such as castability of material and poor shape retention on dehydration limit the effectiveness of hydrogels as substrates for large-scale surface applications. The aim of this research was to develop a hydrophilic, biocompatible substrate material that is structurally stable, castable and retains shape on dehydration while allowing algal cells to adhere to material externally, rather than relying on encapsulation. A marine algae Porphydridium purpureum was selected due to its red pigmentation and high exopolysaccharide contents, which facilitate adherence. A hydrogel composite material enriched with loofah fibres was developed, and its bioreceptivity was tested by applying pre-grown algal cultures. The loofa fibres have a chemical composition of cellulose, hemicellulose, and lignin. Owing to high cellulose content, water absorption allows biocompatibility, while lignin and hemicellulose increase the strength of the material. The material was composed of a hydrogel mix (3% sodium alginate, 4% carrageenan kappa) and loofah fibres in an 8:1 ratio. The mix was applied as a plaster onto miniature brick components and crosslinked with calcium chloride. A series of components plastered with the hydrogel composite material were exposed to intermittent watering with algal cultures within a bespoke irrigation system. The setup was photographed every three hours, and images were included in a timelapse. Additionally, the material was also applied as a mortar between two ceramic bricks to test its binding capacity. The alternate red pigmentation seen in the timelapse results demonstrated the bioreceptivity of the hydrogel composite material. On the other hand, the correlation between red and pink colouring seen with hydrated and dehydrated states show the effects of water on biocolouration of the material. The binding test results showed the material's capacity to act as a mortar when dehydrated, while the compression tests showed a dehydrated sample of the material could bear a pressure of 2.8Mpa with a displacement of 14mm, which is comparable to a regular sundried brick. This research project proposes a castable substrate material for algal growth that can act as plaster, brick and mortar while supporting the growth of marine alga P. purpureum as a strategy for biocoloration.

13.40 – 14.40

Session 2: Engineering Biology for Future Textiles

(Single Track Presentations)

Roberta Morrow

Royal College of Art

Co-authors: Miriam Ribul, Alexandra Lanot, Sharon Baurley

Designing living microorganisms - case study - self-constructing bacterial cellulose fibres for application in structured textile

This project is part of the Bio- Manufacturing Textiles from waste project, led by the Centre for Novel Agricultural Productions, University of York in collaboration with the Material Science Research Centre, Royal College of Art.

Biomaterials need new, innovative manufacturing processes to allow them to be created in the most affective and circular way. Although there is a direct route to scalability by applying biomaterial to conventional textiles manufacturing, this misses the opportunity to directly interact with the characteristics of the material, and to design with these characteristics to create a truly sustainable new material and potentially cut out manufacturing steps.

Regenerative cellulose fibres are manufactured though the processes of wet spinning, traditionally sourced from cellulose such as wood pulp; the cellulose is harvested then processed into a dissolution which is then extruded through coagulant and reformed into regenerated firmaments. In recent years, wet spinning has been applied to other forms of cellulose created by bacteria (bacterial cellulose/nanocellulose). Commonly formed under the umbrella term 'biomaterial', bacterial cellulose (BC) is self-forming and appears at the interface of nutrient-filled liquid and oxygen as a pellicle of interlocking cellulose ribbons. Because of this physical structure of growth, bacterial cellulose has strong mechanical properties. By applying

BC to wet spinning, the bacteria grows into cellulose into a pellicle and then broken it down chemically though dissolution to reform it into the desired shape of a filament, thus losing the inherent strength of its physical formation. Designers of new materials are missing an opportunity to interact with the core characteristics and function of these microorganisms.

1.1 Designing microorganisms Method,

Integrating design knowledge with science.

The future of biomaterial design requires having a breadth of knowledge from design through to biology and material manufacturing. In order to achieve new manufacturing innovation for biomaterials, this collaborative research approach must be in place from the beginning of the process.

1.1.1 Design

Interacting with materials in an experimental way will allow for a core understanding of the design characteristics; these interactions may take from in craft knowledge and tacit application of biomaterials. The idea of interacting with a material from an early stage of development allows designers to understand the core characteristics of the material to create new material systems.

1.1.2 Biology

Understanding the biology of the material allows designers to edit the growth of BC to either enhance a characteristic or change them at the growth stage to suit an outcome.

1.1.3 Textile Manufacturing

Having a core understanding of the manufacturing of conventional textiles allows insight into potential manufacturing roots and processes that can be adjusted and enhanced when in cohabitation with biological and design knowledge.

2. Case study self-formed bacterial cellulose fibres

Using this methodology of combining design, biology and textile manufacturing knowledge, bacterial cellulose was designed to form directly into useable yarns, thus reducing processing in comparison to regenerated cellulose fibres.

Anastasiya Kishkevich
Imperial College London

Co-authors: Charlie Gilbert, Wolfgang Ott, William Shaw and Tom Ellis

Production of engineered living material from kombucha co-culture.

Kombucha is a fermented drink produced by symbiotic culture of bacteria and yeast (SCOBY). Scoby is commonly composed of bacteria from Komagataeibacter spp. and yeast from Candida spp., Brettanomyces spp., and Saccharomyces spp. During fermentation bacteria produces cellulose which forms a pellicle on the air-liquid interphase. Bacterial cellulose is a versatile biopolymer with unique properties such as purity, safety, biocompatibility, mechanical strength and high-water retention and has already found its use in food industry, packaging, medicine and electronics. Bacterial cellulose from kombucha co- culture is a living material hybrid which can be functionalized via genetic engineering of its symbiotic yeast. Previously, we have isolated cellulose producing Komagataeibacter rhaeticus and have developed protocol for culturing synthetic SCOBY (synSCOBY) with genetically engineered Saccharomyces cerevisiae (budding yeast) strain. SynSCOBY is cultured in yeast extract/peptone media with 2% sucrose, where budding yeast naturally secretes invertase to break sucrose into fructose and glucose for bacteria to produce cellulose. In this SynSCOBY budding yeast was engineered to secrete enzyme beta-lactamase which presence can be detected by color change of reagent nitrocefin. We were able to demonstrate that engineered yeast is incorporated into cellulose and secrete fully functional enzyme into the pellicle. Using this approach, we are aiming to produce material from bacterial cellulose with improved mechanical properties and responsive to environmental changes. One of the approaches to make the material more elastic can be incorporation of elastin-like polypeptides (ELPs). ELPs are repetitive synthetic biopolymers with “smart” stimuli responsive properties, such as self-assembly in response to temperature changes. To advance property of cellulose as material we are engineering yeast strains to secrete ELPs which will be then incorporated into growing cellulose matrix. Thus, a network of ELPs in the living material can potentially alter mechanical properties and make material responsive to various environmental factors. Such material can be potentially used in various fields including biosensing.

Katie Gilmour
Hub for Biotechnology in the Built Environment (HBBE)

Co-authors: Mahab Aljannat, Christopher Markwell, Paul James, Jane Scott, Yunhong Jiang, Martyn Dade-Robertson and Meng Zhang

Fibre fusion, functionalized bacterial cellulose through BslA

There is increasing interest in utilising synthetic biology approaches to produce engineered living materials. In nature, biological materials are synthesised and functionalised by constructing complex structures composed of different molecules. For example, biofilms, which provide protection for bacterial cells, constitute a range of functionalities through the addition of extracellular molecules including proteins which enhance strength, flexibility, and hydrophobicity.

Often produced as thin sheets comparable to a non-woven material, current production strategies rely heavily on post-production chemical treatments, or high energy inputs to customize the functional properties. By creating new sustainable methods to produce modified bacterial cellulose, it may have broader applications. One such method could be through a synthetic biology approach, namely, the incorporation of functional proteins. BslA is a hydrophobic protein involved in biofilm formation of Bacillus subtilis, which when applied to bacterial cellulose, could produce a versatile, water repellent biomaterial that could then be used in textile applications such as a sustainable leather-like textile.

BslA was expressed recombinantly with a cellulose-binding module and then applied to bacterial cellulose (ex-situ) or added to initial growth media (in-situ) of cellulose-producing bacteria, Komagataeibacter xylinus. The topography of the resulting cellulose was observed using atomic force microscopy and changes to hydrophobicity were analysed using water contact angle testing. These experiments demonstrated an interruption to cellulose formation on addition of BslA, however, it was concluded that BslA did not display any cytotoxic effects on K. xylinus. A further series of experiments suggested that the cellulose-binding domains did infer localised protein binding to cellulose. Whilst BslA was able to increase the hydrophobicity of the cellulose surface, it was found that the orientation of the cellulose-binding module may interfere with this functionality. Results from mechanical testing of the treated cellulose supported the conclusion that BslA with cellulose binding domains alters the formation of cellulose pellicles, resulting in an increase in tensile strength and decrease in Young's modulus, thus creating a stronger, less brittle material. Therefore, it was concluded that functionalising cellulose using a recombinant protein did increase the hydrophobicity to the same extent as conventional chemical treatments.

11.20 – 13.00

Session 3: Textiles as a Biofabrication Strategy

(Single Track Presentations)

Svenja Keune
(I.N.S.E.C.T), CITA and the Swedish School of Textiles

I.N.S.E.C.T. @ OME/HBBE (UK): Interspecies exploration by biodigital manufacturing technologies

The microclimate is the critical link between any habitat's physical planning (geometry, spatial configurations, material compositions) and its receptivity to living organisms. One may argue that microhabitats are formed primarily because of variations in microclimates.

In the first part of the 2-part INSECT Summercamp, we invited 9 practitioners to design and 3d-print an experimental and living material prototype for the OME. In this workshop we explored clay, living mycelium and textiles in regard to creating different microclimates that are inviting the colonization of insects and microorganisms. Our interest is in the complexity of multispecies habitats introduced into our common built environments, with a focus on insect and microbial life. Their significant importance for ecosystem balances and the present decline of insect biodiversity demands that we urgently develop multispecies design ethics, practices, principles, and strategies that include their perspectives.
The extrusion-based 3D printing of clay and a material-oriented digital design method allowed us to design in scales that are closer to the architectural boundaries of insect nests. In addition to the use of digital technology, we have used the different porosity and tectonic possibilities of crocheting to connect the suspended wall twin and it's materiality (clay, mycelium) with the ground.

We see a necessity of stimulating networks of researchers and practitioners to strengthen the field and to advance the current approaches/perspectives regarding using living organisms in a design process, designing for them, together with them, and designing for and engaging in cohabitation. The wall twin is the first physical outcome of the larger I.N.S.E.C.T. framework/community.

Christine Yogiaman

Singapore University of Technology & Design

Knitted Structures for Mycelium Composites

Mycelium composites are being named a promising bio-fabricated material that is in line with a Cradle-to-Cradle approach (McDonough and Braungart, 2010) and present environmental and sustainable possibilities (Karana, Blauwhoff, Hultink, & Camere, 2018). Bio-fabrication of materials open up novel opportunity for designers to innovate the functional possibilities of the designed output through variations in fabrication processes. Literature has seen an increased interest in this emerging material design practice that has recently been defined as Growing Design (Myers, 2012).

Literature review on what factors contribute to the composite mechanical properties converged at the findings that the combination of factors that increase the thickness of fungal skin and the density of the hyphae network within the substrate correlate directly to the increased mechanical behavior of the mycelium composites. (Appels et all., 2019) This review faciliated research project to develop a new type of permeable textile boundaries controlled with 3D CNC knitted textile graded properties that can mediate and guide cultivation of fungal skin and hyphae growth density, complementing the indeterminate and open-ended process of growth. SEM imaging at the surface of the knitted textile mycelium composite provide evidence that the hyphae is forming an interlocking network with the knitted textile.

The research group explored the potential that material composition of the knitted textile can be calibrated to increase growth of hyphae at the surface through the incorporation of nutrient saturated yarns. Using wood industry and agriculture waste as base substrate, textile moulds knitted with three yarn types- cotton, 50-50 cotton-acrylic blend, and acrylic, are cultivated to test this potential. Three samples of each textile mycelium composite types underwent compression testing. Results show cotton yarn textile mycelium composite has the highest Young's Modulus figure and is the stiffest of the different composites. This initial result opens up the opportunities to calibrate mechanical properties of cultivated mycelium composites with the ability to control textile graded properties using 3D CNC Knitting.

3D CNC knitting enables the fabrication of knitted fabric that has control over the specificity of each knit loop. Tubular Single Jersey is the stitch pattern selected for the mould, as it's a basic lightweight stitch pattern. The knitted mould used a loop length of 7-8mm to widen a typical single jersey loop and improve porosity. This lightweight porous knit stretch freely in both the direction of its Courses and Wales. Ultra-High Molecular Weight Polyethylene (UHMWPE) blended with Spandex and Polyester yarn is used for this base body of the knit mould. The design of the knit includes another stich pattern, Inlays, are made by running a continuous yarn in between knit courses, moving in an alternating pattern in the front and behind a set of knit loops. [Fig. 2]. The inclusion of Inlays that is independent of the base body of the knit mould allow for a freedom to designate yarn types specific to certain calibration. In this prototypical knitted textile mycelium composite structure, the inlay yarns are specified to be cotton or other nutrient saturated yarns that will encourage hyphae growth and increase structural performance of the composite. Figure 2 diagrams the regions of high compression in a branching unit block when vertically loaded, and the corresponding concertation regions of cotton yarn inlays to encourage increase hyphae growth activity.

Our research work expands on the definition of this emerging material design practice, to engage digital design and fabrication procedures in the intersection of biology, craft and design. The aim is to cultivate a new material type – knitted textile mycelium composite that has the capability to augment final material composite properties and provide formal freedom to designers.

Andrew Gennett
Designer

Project Devil's Fingers Façade – C. archeri

A building's façade left untouched bares the full exposer of the sun's radiation, this can lead thermal bridging and warming of the internal environment. This is something desert cacti have face for millennia, to which the response was a mutation in body plan introducing ridges. Vertical ridges act two-fold providing a self-shading system while producing inter-ridgel updrafts drawing air across its surface cooling the internal fluids. Maintenance of internal temperatures are critical to photosynthesis, to which we have drawn a parallel to our own comforts following the same logic in architecture with lightweight shade façades. However poor design often relies on electrically driven systems, as bio-electricity does not exist in the same quantities plant rely on turgor pressure to act quickly. Thus, hydrostatic pressure is our chosen mechanism of action in driving our shape changing shade system.

We therefore have our system constraints:

1. Light weight bio-composite textile façade shading system.
2. Environmental responsive, under solar radiation and wetting from precipitation.
3. Design informed by surface temperature and material properties.

Our textile is a pre-stretched fabric made tensile by embedding with pure mycelium grown into the knit. Balancing the desired surface temperature against weather patterns informs our design patterns, which are additionally constrained by fabric stretchability and wetted mycelium deflection.

Firstly, the bio-composite combines a stretched textile laid over a substrate colonized by a fungus. Upon induced fruiting under controlled conditions aerial mycelium rises off the surface of the block, encountering the knitted fabric whose holes become embedded by hyphae. Passing through the mycelium continues upward, until harvest when the substrate and fresh composite are removed and allowed to dry. Releasing the stretched fabric at the right time would turn the 2D form into a 3D tensile structure.

Second environmental response, while generally fungal hyphae are hydrophobic, they can be processed to become hydrophilic acting as a wick drawing water up the mycelium body by capillary action. By this mechanism our bio-composite has turgor potential, during a precipitation event the disproportional swelling induces a change in shape. The dynamic change though is not only the result of the fungal material, but rather it acts as an enzyme lowering the activation energy of the shading system. It is the tension of the textile that provides the action to change shape, which is reversed when the system dries out again reverting to the normal stable state.

Finally Parametric modelling can consider local weather conditions and material properties while constrained to desired surface exposure and internal temperature. Together these constraints inform the body plan for our environmentally responsive bio-composite textile architecture façade.

Vivien Roussel
De Vinci Innovation Center (DVIC, Paris)

Co-authors: Marc Teyssier

The Meaning and Challenges of Personal Bio Fabrication

The scarcity of resources and the ongoing environmental crisis redefine the status of manufactured objects and our relationship to materiality. Recently, digital fabrication technologies have allowed us to design artifacts and objects with hard matter (plastic, wood, acrylic) without technical prerequisites - changing our relation towards traditional manufacture and craft. New practices exploring biomaterials propose alternative materials in line with the challenges of rationalizing resources and energy. These materials opens-up new opportunities for design and fabrication.

While synthetic biology remains mainly within a laboratory setup, we argue that these fabrication processes will emerge as DIY production alternatives accessible in the individual environment. This introduction challenges the common perception of the status of matter, fabricated objects, and more generally, the meaning of personal bio fabrication. It also challenges the necessary tools to grow and shape the base material and vector of transformation of relationship with the world.
To explore these challenges, we propose "Morphogenesis", a bio-fabrication machine capable of growing functional biohybrid artifacts in 3-dimensions. We rely on computer-aided design and knitting techniques to create composite objects composed of anisotropic bacterial cellulose combined with textile yarns. Inspired by Critical Design, this machine allows us to speculate on the near future of fabrication. The creation of technical objects to support the emergence of hybrid and living "things" is support for reflection on the design and rationality of objects in the philosophical fields. To understand the meaning and the challenges of bio-based fabrication, we propose the conceptual framework for "the morphogenesis of objects through matter" that empowers designers and makers to rethink the status of objects.

The conceptual framework divides the creation of bio-hybrid objects in four steps.
1) The Initiation. The maker designs a physical artifact whose functions meet a functional need or explore the material capabilities. This step is semi-directed by the creator, who must acknowledge that its “intuition in act" will be influenced by living matter.

2) The Propagation. The object is emerging. Our growth model permits fabricating bio-hybrid objects similar to plant culture, while the monitored machine guarantees the optimal conditions for bacteria growth.

3) The Mitigation. The object is shaped and takes form in the milieu. The bio-artifact drying process in the dehydrator influences its final shape, similar to how the craftsmanship finishes a piece.

4) The Exposition. The object is taking its place in the social artifact context, challenging the social acceptability. Its properties tackle the dialectic paradigm of artificial/natural artifact. Our conceptual theory relies on modern material-psychology and anthropology literature. We affirm that the biohybrid objects are the emergence of reconciliation between Technique and Nature rather than their classical opposition. From the Cosmotechnics of Yuk Hui and the Tim Ingold sensibility on craftsmanship symbiosis with silkworms, we build with the Morphogenesis machine a framework to think of growing objects and alive composite matter as alternatives for local manufacturing - beyond simple "bioinspiration". This proposition, formed as a discussion for practitioners, supports discussion on the resource circularity and sustainability as a symbiotic milieu with the technology.

Romy Kaiser
Hub for Biotechnology in the Built Environment (HBBE)

BioKnit

The BioKnit Prototype provides a novel solution to upscaling mycelium construction and explores more organic and tactile approaches to architecture. It explores how 3D knitted fabric can be programmed and applied structurally at human scale using fungi, bacteria, and simple physics.

The research brings together biotechnology, digital fabrication, and computation in the production of a monolithic free-standing biohybrid structure. The prototype is composed of mycelium (the root network of fungi), cellulose (produced by bacteria), and 3D knitting (knitted from wool and linen). These materials have a dramatically lower environmental impact compared to conventional construction materials and provide the opportunity to radically rethink how we build.
BioKnit employs knitted fabric as a scaffold and scaling agent to guide the growth of mycelium and form a bespoke composite. The structure provides the framework to host 2m long bacterial cellulose panels pre-grown to predetermined shapes. Uniquely,

the knitted formwork enabled the 1.8m high, 2m diameter structure to be grown as a single piece. The prototype demonstrates that the mycelium-knit composite has sufficient compressive strength to support a free-standing, slender vault.
The design workflow integrates computational modelling with knit programming to create specifications for branching preforms produced using 3D knit technologies. Research findings include the optimisation of fabric parameters and mycelium substrate mix, protocols for large scale textile biofabrication and protocols for working with mycelium and bacterial cellulose onsite, in nonsterile conditions.

Research Team
Jane Scott, Ben Bridgens, Elise Elsacker, Armand Agraviador, Romy Kaiser, Aileen Hoenerloh Dilan Ozkan, Ahmet Topcu

14.00 – 15.20

Textiles as an Interface for Multi-Species Collaboration

(Single Track Presentations)

Oscar Tomico
ELISAVA University

Co-authors: Ron Wakkary, Kristina Andersen

Living-with/Designing-with plants through cohabitation

This presentation focuses on the experience of cohabiting with plants through an IoT domestic infrastructure. It investigates extending ideas of “living-with” and “designing-with” through self-reflective autoethnographic investigation. In the last five years, the first author lived with up to 250 plants that have shaped and reshaped his home, becoming an entanglement of technologies, plants, humans, and others. Practically, this has been materialized through multiple iterations of aggregating and hacking off-the-shelf technologies that have created an assemblage of smart lighting, humidity, and watering systems to foster and materially explore cohabitation. Through this process, co-habitation has both been the goal and the way living-with/designing-with was explored. A series of 1st person research vignettes supported by photos have been collected to illustrate the shifts of attention, frictions, and transitions behind this process. Analyzing them allowed to discuss its implications and opportunities related to 1st person research, posthuman design, multi-species collaborations, and sustainability in HCI. Ultimately, the investigation is an exploration of cohabitation in a multi-species context and the co-shaping of habitats for both diversity and as a means of resistance to anthropocentric understandings of designing technologies that shape our environments.

Paula Nerlich

Hub for Biotechnology in the Built Environment (HBBE) & Driving the Human (DtH)

The Human-bacteria interfaces (HBI)

The Human-bacteria interfaces (HBI) concept examines how multi-modal interactions between humans and microbes can elicit novel ways for humans to 'meaningfully' collaborate and co-exist with the nonhuman within the built environment. Specifically, HBIs are tangible, living interfaces consisting of microbial consortia that interact or respond to stimuli from their surroundings by emitting signals accessible to humans through touch, smell and sight.
With our HBI, we explore designing through and with the other, encountering more-than-human realities that invite us to dive into new perspectives. To understand the other's needs, perception and possibilities in interaction and co-habitation.
By aiming for a multi-species and more-than-human perspective, a new understanding of the other is nurtured, might this be human, non-human, living, non-living or whole ecosystems. This allows to challenge current eco-social and political systems that not only affect existence on Earth but also humankinds journey beyond and feeds new thinking into modes of multi-species co-habitation and negotiation between diverse agents.

The Human-Bacteria Interfaces concept explores new relationships with microbes through science-based speculative prototypes. Similar to other species and matter on Earth, microbes can respond to signals and stimuli from their surroundings.

A core element of this concept is examining the potential of designing microbes to become living sensors that can respond through light to stimuli based on their genetic design. By designing new interactions with microbes, care and concern for other nonhuman living beings become a conscious part of our everyday experience. At the heart of this concept is a narrative that explores a biophilic turn within the generative genre of design: what if we could design through partnerships with the nonhuman living world (such as microbes) rather than relying solely on the industrial extraction of matter to create the increasingly complex world that surrounds us? How could new relations with microbes build our future homes?

Research Team: Paula Nerlich, Romy Kaiser, Beatriz Delgardo, Anne-Sofie Belling

James Forren
Dalhousie University

Co-Authors: Hugh MacIntyre, Laure Nolte, Cat London, Esther Fu, Kirby Rushton, Matt Sealy, Alexander Crosby

Investigation of Living Building Materials (LBMs) to reduce Farming and Construction Impacts

This paper presents a multi-part investigation of living building materials (LBMs). The LBMs investigated are: 1) microcalicte precipated (MICP) slurries, and 2) cellulose and xantham gum based slurries. The work is conducted across/between two laboratories – architecture and oceanography. The investigation uses a general feedstock-conversion-utilization workflow. Goals of investigation are to: 1) tie production of living biomass to intersected feedstock waste streams; and 2) utilize local ecosystems for suitable local candidates for LBM production, and 3) adaptation of LBM to additive manufacturing production, thus filling gaps in current LBM landscape (cf. Heveran et al., 2020; Crawford et al., 2022). Preliminary findings are: successful growth of biomass feedstock on food-production effluents; growth of suitable algal candidates for MICP and proof of concept test data; successful growth of terrestrial fungi in waste- amended seawater; and clay slurry toolpath production.

The biotic component of the investigation is the production of living biomass (phytoplankton and terrestrial fungi) in seawater amended with nutrients from various waste streams—whey permeate, vinasse, and fishery waste digested through hydrothermal liquefaction (HTL). These are derived from the environmentally intensive human activities of food production with the motivation to "explore strategies to cultivate and grow new materials that have the potential to radically reduce the impact of our industries". The ambition is to produce building materials from the waste streams of other environmentally intensive industries: thus creating a fly-wheel effect of harm-reduction in building materials and farming by utilizing the waste in one to offset or reduce the environmental impact of the other.

A further benefit, or investigation, is the unique material properties and spatial and material potentialities offered by the LBM outcomes. These include material characteristics of thermal performance and hygro-scopic/-phobic performance in addition to enhanced or augmented mechanical behaviour. Additionally, these require an understanding of human behaviour and response, and the cultural implications of recycling.

The paper will present background on the study context and early-stage findings of the architecture- oceanography collaboration at various stages of LBM production. These include: screening candidate isolates of phytoplankton and terrestrial fungi for growth in waste-amended seawater; optimizing biomass production, harvesting, and dewatering; and production and testing of LBM prototypes. It will then outline next steps in the investigation, including methodological plans for translation to additive manufacturing production.

The study considers remediation of the ecological footprints of agriculture/aquaculture through architecture and design, optimizing the process through tuning of genotypic and phenotypic variation in the responses to the waste streams on one hand and to production of the architectural/design elements on the other. This involves selection for and facilitation of multiple metabolic pathways, balancing both photosynthetic and heterotrophic cultivation to maximize the remediation of the waste streams and to optimize the mechanical and design properties of the LBMs. Diversion of the waste streams to building materials in this way has the potential to reduce the environmental harms of extraction, toxic processing, and ultimately coastal eutrophication and to act as a carbon capture technology by trapping biotic carbon in the LBMs in an emerging circular materials economy.

Thora Arnardottir
BioBabes & Hub for Biotechnology in the Built Environment (HBBE)

BIO-centric collaborations: Re-DESIGNING perspectives and our relationship with nature

BioBabes is a collective of experienced designers and researchers working with various biomaterials and fabrication methods, including living organisms, organic matter, and biomimetic and biosynthetic processes. We see our work as an intersectional practice joining different areas of technology, science, and creativity. The idea behind it is to re-connect the living and the inorganic, the naturally adapted and the designed, overcoming the separation between the biological and the artificial, culture and nature. As an intersectional practise, we aim to create connections and re-design our perception of the living environment and our relations with production and consumption paradigms. Furthermore, we work to develop the emerging field of biodesign and to disseminate its principles to a broader audience through innovative techniques, concepts, and biofabricated design pieces.

To highlight our approaches, we focus on projects that have shaped our idea of working with [a non-human organism] by re-designing habitats for microorganisms that magnify and highlight them as part of our wardrobe. As emphasised in the Future Wardrobe project, we worked with living algae and approached them not as a resource but as our client. A non-human client to whom we structured our design methods to accommodate the nurturing of its needs. We applied processes and techniques that are bio-centric. As a result, our designs and products are embedded with strong statements and invitations to challenge the status quo.