Stretching Spaces

Co-Inhabiting the Exhibition Space as a Base for Transdisciplinary Research

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The singular, infinite space of the universe is continuously stretching—expanding itself, becoming even more infinite. This does not mean the universe is growing into pre-existing space but that the fabric of space itself is changing. Cognitive space has never been singular, as human experience has always unfolded within multiple interconnected spaces that are all contributing to our perceptions of reality. What we perceive to be happening around and to us is a dynamic network of environments and signs. Recognizing this multiplicity is a way to acknowledge more-than-human modes of existence and to overcome dichotomies such as »nature–culture,« »analog–digital,« »human–non-human,« »growth–decay,« »conservation–waste,« or »social–scientific.« Rather than understanding space as a container for matter, the exhibition *Stretching Materialities* involved experimenting with the interactions with the space-time of matter activity and »understanding humans and nonhumans in their mutual constitution, as integral parts of the universe—not as beings in the universe« (Barad 2003, 169).

What is the meaning of the plurality of »stretching spaces« when the elegance of outer space lies in its unity and continuity? Space can be defined as the infinite, non-computable, multi-dimensional realm in which all matter and events occur. It is not simply a void; it accommodates matter and events. Space provides room for movement and, through a multitude of possible movements, carries memories and potentialities. Portions of this same space (*spatium*[1]) are all around and within us, while the porosity and filamentation of matter allow spaces to interconnect.

The exhibition *Stretching Materialities* conceptualized some of these in-between spaces—such as the space found inside the cell, in between plaited willow tree branches, around a droplet of fog, within the zero (0), or along the ridge of a stone. Making these designated spaces accessible for an immersive, attentive dwelling within and through scales and speeds—from atmospheres to cells and back—reveals the hidden activities of matter. The exhibition space itself thus appeared as a larger, continuous common space where these activities simultaneously occurred. Sensing events at different magnitudes unfolded a multitude of possible spaces and created opportunities to grasp their intrinsic interconnections.

Architectural space, like the vastness of outer space, is a concept, a model, a construct in constant flux—a framework for

1 From the Latin spatium for »room, area, distance, stretch of time«; also a portion of space (Deleuze and Guattari 1987, 481).

interpretation and articulation. To make the multiplicity of spaces more palpable, we can approach the exhibition space that organizes, affects, affords movement, and moves as a shared habitat: the object-space; the habitat of collected matter; the culture-spaces for collecting and archiving; the experiential space for participants in motion; the habitat for indoor air, stones, plants and micro-animals, for employees and researchers. Thinking about matter and exhibiting through inhabiting and *becoming*, rather than just visiting or existing, revealed mutual interdependencies and temporalities within the exhibition space (fig. 1). → Stretching Practices, 43 In this way, biographies of research processes and materials, experiences, and environments—such as laboratories, willow fields, and server infrastructures—were introduced into the realm of the exhibition. ❑ Process, 284

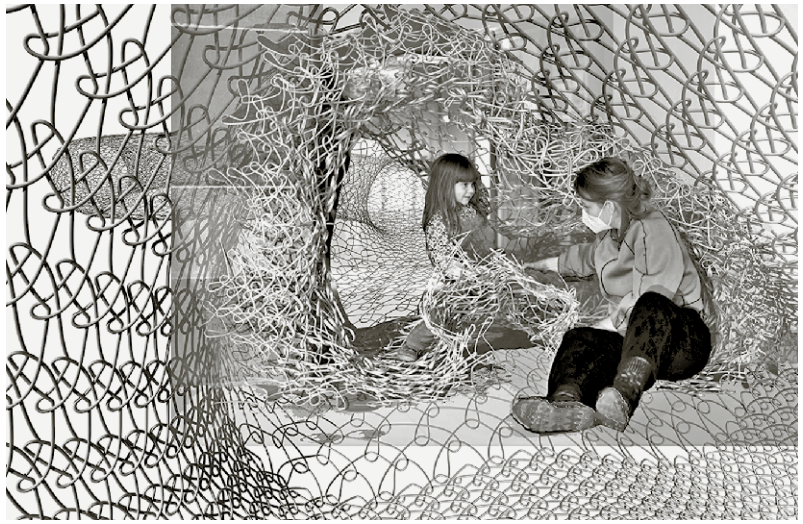


Fig. 1: Co-inhabiting the exhibition space: the accessible space knitted transdigitally allows for inhabiting the fold between the analog and digital

Researchers from different disciplines created spatial constellations that revealed possible ways of inhabiting the exhibition space and invited visitors to enter and co-act in this realm of potentiality. These spatial constellations became an apparatus for revealing the societal value of matter and reimagining futures. Visitors became, potentially, actors—participants. → Intermezzo 2, 116

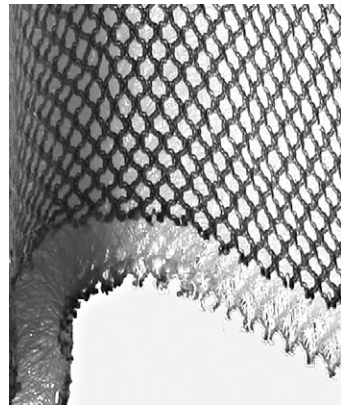
Exhibiting, in the context of object conservation as a spatial practice, engages one into rethinking the making of spaces. Architecture—built, grown, computed, woven—can be considered a multi-scale homeostatic, collective self-preserving practice, a semipermeable layered membrane between objects, bodies, materials, and environments. → Stretching Time, 222

Like a cell membrane that separates the internal contents from its surroundings while affording the flow of matter and spaces at the same time, the lower atmosphere shields us from cosmic radiation. The biosphere accommodates life, conditioned by urban tectonics and coated with clothing, creams, and other regulatory interfaces. Through technology, prosthetics, clothing, carpets, buildings, and pavements, we extend and stretch our organisms, engaging in new modes of inhabitation. The architectural process encompasses weathering and intra-weathering—metabolic and dynamic forces where all designated »things« are in constant exchange and in inseparable intra-action with the environment (Barad 2007, 141).

2 Self-reflection used in critical theory is revisited using Donna Haraway's term diffraction to include different ecologies.

Textile Spatiality

The concept of *Textile Spatiality* explores these exchanges through accessible, filamentous, wearable, and sonic climate-responsive architectures, created in a transdisciplinary context. These experimental structures have the potential to become immersive apparatuses for self-reflection and *diffraction*[2] or mirroring, while allowing another kind of critical consciousness, making explicit the material, social, and spatial entanglements of diverse ecologies (Haraway & Goodeve 1999, 102). Historically, while relating greatly to textile knowledge, the word *textile* is avoided both in architecture and philosophy. The relational and processual materiality within digital and social realms and natural sciences calls for change. The void in the textile is as fundamental as the material itself—its emptiness affords interactions, making it palpable. Filamented structures are open to weak interactions with space and matter, intra-actions, and becoming, forming a tool for what Haraway calls *tentacular thinking* (Haraway 2016, 32; Barad 2007, 151), a mode of understanding that emphasizes the connection and relationality across species, systems, and timescales and resists individualism and fixed boundaries.



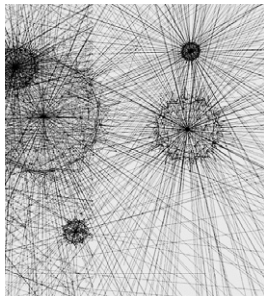


Fig. 2: Textile spatiality in the weaving code (a), between spatial filaments (b), and in-between double-layered spacer textile research (c)

Textile spatiality thus redefines simultaneously spatiality and materiality, engaging with the interplay of material, immaterial, and spatial, presence and absence. Together with the textile and digital realm, the sonic aspect–polyphony–offers a means to grasp the complexity and multi-scalarity of planetary processes such as climate and resources. As an architect, the concept of textile spatiality is rooted in years of my practice, experiments, and exhibitions between art, architecture, and sustainable building, from the EXPO 2010 Shanghai pavilion City Code (fig. 2a), and large-scale installations toward a lighter-than-air city (fig. 2b) and multilayered textiles, so-called spacer textiles (fig. 2c) at Frankfurt University of Applied Sciences, and the sonic design of sculptural organ instruments KLANG, LUFT UND LICHT with the art collective *dreidreidrei*). → Stretching Senses, 296

Influenced by the urban imaginaries from art and architecture of the 1960s and 70s, these spatial experiments draw from physics, mathematics (bubble and geodesic geometry), biology (water distribution, filamentous fungi, spider webs), and textile structures (symbolic and technical). They extend beyond biomimetics, where principles from nature are applied in design addressing relational processes such as adaptation, growth, and cohabitation.

The plasticity of materials and environments as habitats and human awareness as habits form the foundation for teaching and research methods toward a new culture of spaces and materials. The focus is on planetary resources and trans-digital–simultaneously analog and digital–spatial sensing. The experiential architectural scale is needed to activate this plasticity through action–the hands-on space making and experiencing through bodily movement.

Exhibiting opens up the research to the public, and thus to further generations and disciplines. Starting from the progression of textiles as hierarchical structures from fiber to yarn (entangled fibers) to fabric, new stances are introduced (Eadie & Ghosh 2011, 761–775): the filament becomes an interactive form for growth, flow, and movement, enclosed or layered fabric that forms textile space.

Textile spatiality stretches into new scales–from the nano-scale of metabolic processes (Miodragović et al. 2024, 63) to the inhabitable scale of *Stoff* (fabric) as architectural mediation. While analyzing filamentous propagation across

ontologies, we explore how networks and textiles act as human *extended organisms*. The concept emerged through the investigation of exhibiting as an architectural research method, *Stretching Materialities*.

Structural Textiles–Plektonik is a situated architectural work of research into self-supporting material systems and planetary resources made from warp-knitted fast-growing woody plants like rattan and willow (rather than timber). Conducted at *Matters of Activity* (MoA) in a transdisciplinary manner, it brought together architects, artists, microbiologists, and material scientists. The research is twofold: the architectural material system and exhibiting as a research method.

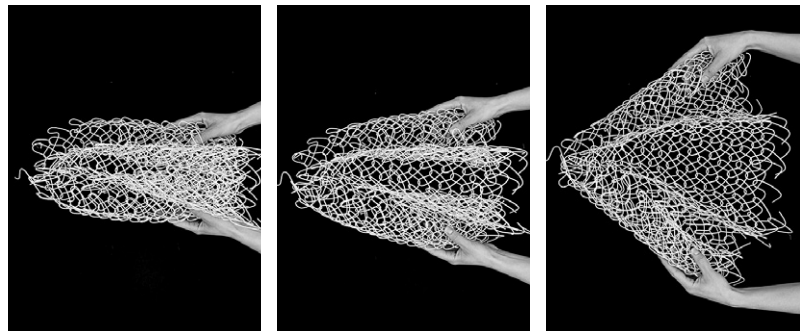


Fig. 3: Unlike weaving, knitting the surplus of material during fabric formation allows for adaptive geometries

For the exhibition *Stretching Materialities*, responsive rattan and willow installations, plaited digitally, industrially, and manually, acted as both exhibits and living spatial instruments. The meta-types–ever-evolving prototypes–from the Structural Textile research became models for material porosity and spatial affordances, allowing to investigate how spaces from different scales can be accessed, inhabited, and engaged (fig. 3). Engaging with the exhibits, by wearing and accessing them, these plaited installations challenged the boundaries of the exhibition space itself, reframing it as a habitat rather than a location. This research employs a warp-knitting technique and wooden branches generating complex geometries that remain stable under compression, breaking conventional limitations of textiles. The use of both imported and local biomaterials brought other places and ecologies into view: rattan and willow possess a healing capacity, remediating troubled landscapes, soil, groundwater. → Stretching Practices, 33 These plants, or materials, are the livelihood for their communities, and, as anthropologist Stephanie Bunn argues, basketry, as a mind-body operation even has healing capacities.[3]

3 »While a person is ostensibly doing one thing when basketmaking, they are actually integrating many areas of life and many ways of using the mind and body in that one task–spatial, rhythmic, memory, sensory, emotional, communicative, mind, mood.« (Bunn 2019)

The exhibition-based research allowed us to examine the very structure of architecture as a discipline. Situating knowledge is not a new form of architectural research, but it is becoming increasingly integrated within teaching and research methodologies. Critical spatial practices, a term developed by Jane Rendell, explore the »in-betweens-theory« and practices, art and architecture, and evolve through transdisciplinarity and specific situated engagements (Rendell 2006, 30). Together with established exhibiting methods in architecture pavilions, installations, digital fabrications, material exhibitions, and prototyping, by engaging with transdisciplinary spatial practices, exhibiting itself became a research method—not merely a constitutional element of architecture but an epistemic tool—one that actively contributes to the production, questioning, and dissemination of architectural knowledge.

Relational Mediality of Textiles and Lightweight Architectures

A concept needs a precept. Accessible installations provide an experiential grounding by enabling embodied engagement and mediating immersion in material and environment. I grasped this when a sociologist reflected on entering the spatial art installation that I was working on at the Venice Biennial in 2009 (*Galaxies Forming along Filaments, like Droplets along the Strands of a Spider's Web* with Tomás Saraceno, fig. 2b):

> […] you can take it, as I do, as a model for social theory, but you could just as well see it as a biological interpretation of the threads that hold the walls and components of a cell. […] No visual representation of humans as such, separated from the rest of their support systems, makes any sense today. (Latour 2011)

While gaining momentum in architectural research, the relational mediality of threads and textiles has become a focus in numerous contemporary art exhibitions—even a decade after the *A Survey on the significance of textiles in contemporary thought and praxis* was published in *Texte zur Kunst* (Buchmann and Frank 2014). Fiber art and textile sculptures that were historically overlooked as media of abstraction have been revisited in major exhibitions such as Art & Textiles (Kunstmuseum Wolfsburg 2013), Fiber: Sculpture 1960–Present (Institute of Contemporary Art/Boston 2014), Freespace (Venice Biennale 2017), Taking a Thread for a Walk (MoMA 2019), Women in Abstraction (Pompidou 2021 and touring), and Milk Dreams (Venice Biennale 2022). Philosopher Yuk Hui suggests that relational materiality is made visible and explicit under digital conditions. The term »relational materiality« is a contemporary response to Jean-François Lyotard's »the immaterial material« and »… [a]gainst the conventional conception that relations are immaterial and also contrary to a substantialist analysis of materiality« (Hui 2015), expanding on the notion of intra-action by Karen Barad.

Mathematician and weaver Ellen Harlizius-Klück traces how Ada Lovelace established weaving practices and the Jacquard Loom as precursors of digital calculating machines, reflecting on the interdependencies of textile and the digital: »We may say most aptly that the Analytical Engine weaves algebraical patterns just as the Jacquard-loom weaves flowers and leaves.« (Lovelace 1843, 696, cited by Harlizius-Klück 2017, 176)

Only recently, established digitalization of practices resulted in integrating textiles into architectural education and research.[4] The turn toward sustainable materials has intensified interest in filaments and fibers, as fibers are main motives in nature (Fratzl & Weinkamer 2007). The heterogeneous, structured material calls for a radical rethinking of materiality. The hierarchical, polyphonic, material distribution in nature—the same material defines densities, structural and dynamic areas as in bones—is also achievable with computed additive techniques such as 3D printing by structuring and material distribution. Citing Neri Oxman, architect Professor from MIT Lab (Oxman 2010), Wolfgang Schäffner sees the possibility for a different, transdisciplinary structuralism coming from architecture and design (Schäffner 2016). To contribute to these thoughts—based on studies where heterogeneous material is achieved through digital fabrication—it can be suggested that such heterogeneity is also achievable through textile structures. These structures follow the logic of textiles, from fibers, filaments, and weak interactions to yarns, fabrics, and textile spaces.

Techniques of textile spatiality in architecture are based on hands-on textile crafting knowledge, engineering lightweight spatial structures, and digital processes. Textile knowledge was part of architectural education only at Bauhaus from 1919 to 1933. However, the influence of designer knowledge that originates in the Bauhaus textile workshop, although essential for contemporary architectural research, is not accredited as such. Thanks to

4 For example, the Centre for Information Technology and Architecture (CITA) and ETH Zurich conduct intensive research into digital knitting, while the University of Stuttgart Institute for Computational Design and Construction focuses on robotic winding and Fibrous Architecture.

recent exhibitions and studies,[5] we have a better understanding of the commitment and impact the designers had on contemporary art and architecture. They paved the way for textiles beyond craft and for the relational mediality of textiles.[6] Using the vocabulary of architecture and art, it was possible to confront »a long-standing assumption in art history that craft is a manual or technical, but never an intellectual, art« (Smith 2014, xxi). Gunta Stölzl led the Bauhaus textile workshop before founding a textile company. Lilly Reich developed the concept of adaptive open spaces with mobile, wall-like curtains.[7]

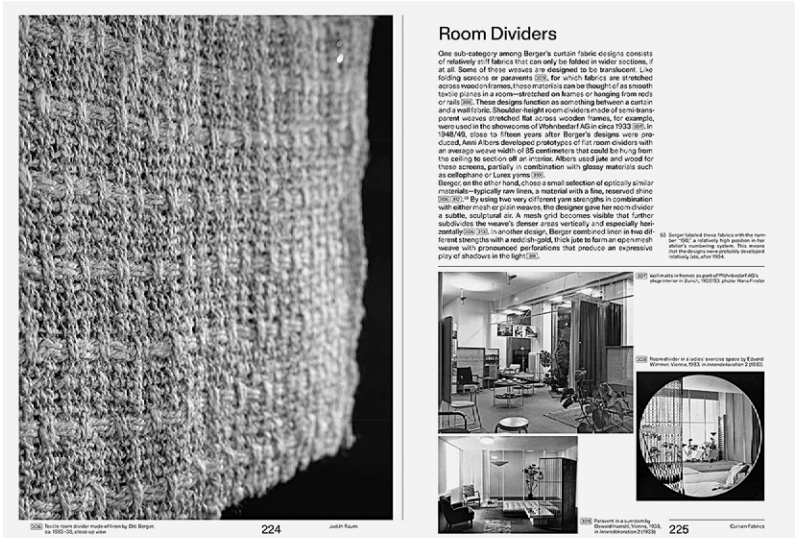


Fig. 4: Spread from *Otti Berger. Weaving for Modernist Architecture* by Judith Raum for the Bauhaus–Archiv/Museum für Gestaltung, Berlin, 2024

Otilija Berger, known for her novel research under the name of Otti, developed textile terminology still in use today, as shown in studies by Judith Raum and her team (Raum 2024). Working with materials like nylon, wood, cellophane, and ramie, they redefined textiles as assembled structures rather than mere materials, as defined recently (Vincent 2008), establishing their application in industry and architecture (fig. 4). The transition from naturalistic motifs to geometric designs in textiles influenced non-representational architectural forms.

With the outbreak of WWII, a number of artists moved to the US, including exiled scholars from Bauhaus. Thanks to Annie Albers, textiles became part of architectural education at Black Mountain college from 1933 and at the New Bauhaus in Chicago from 1937 onward, with Marli Ehrman leading the textile workshops. With actors around Buckminster Fuller, interdisciplinary synergetics research on dynamic structures that draws from natural sciences and lightweight architectures related to traditional textile architectures, such as the Mongolian yurt, came into contact with spatial textile logic. Kenneth Snelson's research into weaving defined tensegrity structures as using tensional integrity as their structuring principle. The lightweight structures have optimized dead load, the weight of a structure itself–thus, the structurally employed material reflects the gravity-defying forces of the active, live load. Membranes, tents, domes, pneumatic structures, spatial trusses, folds, and shells as well as optimized concrete structures all encompass lightweight structures. Initially they were not studied in the context of textile knowledge. They often reflect the anticipation of an emancipated, progressive society, and independence after colonialism gained momentum in post-war architecture also in South America with Felix Candela, Eladio Dieste, and in socialist countries with figures such as Ulrich Müther in the GDR. These optimized spatial structures can also be deployable and mobile, spanning areas in temporary infrastructures like stairs and bridges, shelters and housing, meteorology, aero- and astronautics, and prosthetics. They follow the forces of the material. Modeling these structures is an inspirational and empowering process–using a small amount of material to practice space-making, or better even, space-taking. Body spaces, and particularly collective body spaces, are essential for teaching in architecture.

The exhibition *Weaving Beyond Bauhaus* (Art Institute Chicago 2019) traces the network of influences that originate in Bauhaus textile research. The first textile artist and designer with a solo MoMA exhibition (1949), Anni Albers published *On Weaving* in 1964, which we still use for reference today. The emancipation of educational and exhibiting politics led artists to engage in challenging conventional spatial practices, among others, Lenore Tawney, Sheila Hicks, Else Regensteiner, Ethel Stein, Claire Zeisler, and Eva Hesse, who were studying with Bauhaus alumni in Chicago and Yale, Gego, an architect and engineer trained in Stuttgart, Lydia Pape, Lydia Clark, Hélio Oiticica from Brazil, and Magdalena Abakanowicz, Ritzy Jacobi, and Jagoda Buic from socialist Europe. With their experiential spatial interventions, investigations of relational forms, materials, and processes, their work can be examined as post-structuralist, or criticism of structuralism–

5 See the international research project and exhibition *bauhaus imaginista*, Haus der Kulturen der Welt Berlin, 20.9.2019–12.1.2020, the accompanying exhibition catalogue (von Osten & Watson 2019), and the online journal *www.bauhaus-imaginista.org/concept*, 2018–2020.

6 Joined by the Constructivists who defined art objects as laboratory experiments and the combination of faktura, material properties of an object, and tektonika, its spatial presence.

7 Velvet Silk Café in Berlin, which was designed in 1927 by Lilly Reich and her partner, Ludwig Mies van der Rohe, was part of an exhibition about women's fashion. The pioneering concept can be defined as temporal textile spatiality.

»supple structuralism« (fig. 5). → Stretching Virtuality, 83 Their work is essential for contemporary architectural research. Along with the Situationist International, they paved the way for an architectural practice undertaken as spatial agency, rather than merely the art of building and constructing.

8 Architecture exhibitions at the German Expo Pavilion (1967), Multihalle Mannheim (1974), and the Munich Olympic Stadium (1972) conceptualized architecture as an adaptive, evolving environment rather than a static form.

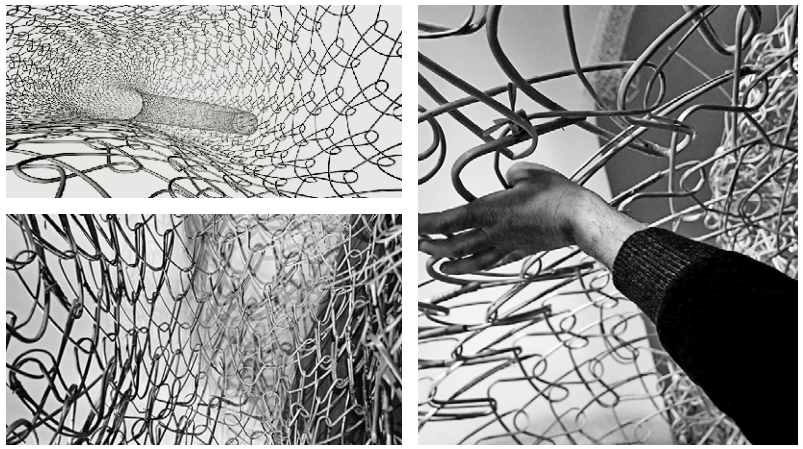


Fig. 5: Inside textile space—an experiential spatial intervention for relational investigations applied in architectural research

The Apollo program led to major breakthroughs in textile science and engineering, and the Blue Marble photograph of the Earth taken from the moon orbit in 1968 catalyzed interdisciplinary discourse, integrating ecology, anthropology, media theory, and architecture into a networked perspective: »Architects must be as networked as the spaces they produce.« (Wigley 2001, 88)

Textile logic shaped architectural education and research at the Institute for Lightweight Structures (IL) in Stuttgart, led by Frei Otto since 1964. Their studies, early examples of parametric design, used material behavior to drive architectural form-finding[8] and made IL a global center of lightweight and biomimetic construction. At the dawn of the twenty-first century, Frei Otto lamented in a lecture at DAM Frankfurt (2000), »we failed«—a reflection on architecture's struggle to integrate sustainable, material-driven design into mainstream construction. Yet, digital design and fabrication research have since revived these principles.

The most precise use of textile techniques for defining space and spatial relations in philosophy is offered by the distinction between the smooth and the striated in *Milles Plateaux* (Deleuze & Guattari 1987, 481)—felt and woven fabric describe the spaces of different intensities and their mixes, smooth and striated, nomadic and stationary, war and state apparatuses. Textiles are used in their paragraph on the *Technical Model of Space(s)*

alongside the musical, mathematical, physical, maritime, and aesthetic models. *The Smooth and the Striated* also touches on knitting, embroidery, and crocheting, elaborating on quilting as a practice of women's collectives and spatial appropriation. North American patchwork, shaped by migration and communal practices, not only bears the names of trajectories, it is inseparable from movement in an open space.

Bernard Cache used Semper's *Stoffwechsel* theory and Deleuze's notion of spaces of different intensities is defined through textile techniques as a tool for discrete architectural materials and structures during early digitalization in architecture. Hence, textiles today would be the abstract procedure emerging within the transposition process that leads us from primitive fabrics to contemporary modulation techniques (Cache 2000).

Written on the verge of digitalization,[9] such post-structuralist theories significantly influenced architectural and urban theory. Architecture started to disappear in glass reflections and deconstructed spaces. With digital tools it melted into constructed landscapes and complex geometries—merging spheres into meta-balls, multi-domes, and blobs—dissolving rigid structures and paving the way for textile logic and »supple solids.« In parallel, the terminology that draws from filamentous logic is used in theory for defining the relations with the environment—intertwining, meshwork, fold, network, entanglement, line, textility, foam, membrane, plasticity, supple solid, rhizomic, and tentacular (fig. 6). → Stretching Practices, 43

9 See Deleuze and Guattari's writings on the rhizome (the *Rhizome* chapter first published in 1976, then as introduction in Deuleuze & Guattari 1987) and *The Fold*, 1988

Fig. 6: Entangled and intertwined—inhabiting the meshwork, network, textility, plasticity, supple solid, rhizomic, and tentacular

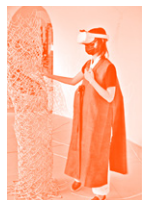
Textile philosophy is written by means of engaging and making (Dormor 2020). This terminology stemming from textiles is used to address a shift towards processuality. Ingold (2002) positions weaving as the ontology of making to address the processuality of materials against a hylomorphic model of creation in which practitioners bind their own pathways or lines of becoming into the texture of material flows comprising the lifeworld. He also re-introduced Deleuze and Guattari's term entanglement used

by Ian Hodder (2012) to define the interdependent relationships between humans and things. Ingold proposes the notion of meshwork, the web as an extension of the spider, to give a better sense of rhizomic and flows of force and lived gatherings than does the term network. Actor Network Theory's »network« refers to the complexities of linkages that relates things beyond their supposed existence as stable regional entities. Catherine Malabou uses neuroscience, therm plasticity, and textile-like behaviors to address its adaptability and potentiality: »Plasticity is the power to receive form, but also the power to give form or to annihilate form. Habit embodies this double movement: it is a repetition that is never mechanical but always contains the potential for transformation.« (Malabou 2010, 12)

Textile Spatiality in (Natural) Sciences: Filamentation

Filamentous bacteria form biofilms in response to environmental stress, growing laterally rather than by dividing, ensuring survival in fluctuating conditions. ❑ Exhibition, fig. 23, 142 Filamentous structures (Østerlund, Persson & Nikoloski 2023, 452–462) pervade biological and physical systems, from cytoskeletal elements and leaf venation to vascular networks, solar filaments, and the cosmic web. Cytoskeletal filaments provide cellular support and transport; vascular systems distribute nutrients; solar filaments influence space weather; galactic filaments define the universe's large-scale structure. Across biology, filamentous forms unite eukaryotic kingdoms–Animalia, Plantae, Fungi, Chromista.

Prior to the *Stretching Materialities* exhibition, the online TA Tour enabled digital exploration of the TA T building through augmented reality, revealing spaces typically hidden from public view. → Stretching Practices, 27 The porosity of space—both digital and analog—was palpated with tentacular pixels: digital images of filamentous structures. Filamentation and semi-permeability in exhibiting and architecture were explored through scans of mycelium, cosmic web visualizations, and cosmic ray imaging. Rendered visible, cosmic rays transform even stone into semi-permeable material, something seemingly as porous as textile. This sparked new interdisciplinary dialogues and projects. Collaborations with polymer physicist Fardin Gholami led to novel insights into nano-scale textile, like molecular structures, extending into projects such as *The Sensing Knife* and *Haptic Hanbok*. → Stretching Senses, 299 ❑ Exhibition, fig. 25, 143



10 Project *Active Curtain*: Natalija Miodragović (project lead), Nelli Singer, Daniel Suárez, Christiane Sauer, Bastian Beyer, Iva Rešetar, Stefanie Eichler, Juni Neyenhuys, Regine Hengge, Skander Hathroubi, Cécile Bidan, Michaela Eder.

The research on formable wood and warp-knitting, foundational to *Structural Textiles*, began with *The Active Curtain Project* (*After Nature* exhibition, Humboldt Forum, Berlin 2020–2025) and continued through *Stretching Materialities*. Like an extracellular matrix in biofilm, the five by five-meter large fibrous scaffold–a structure that fosters growth, whether in biological tissues or construction–showcases interdisciplinary research on cellulose through its void-defined structure. By developing prototypes, cellulose and bacterial cellulose are studied in collaboration with the Weißensee School of Art and Design at the intersection of microbiology (Humboldt-Universität zu Berlin), materials science (Max Planck Institute of Colloids and Interface), and architectural design (MoA).[10]

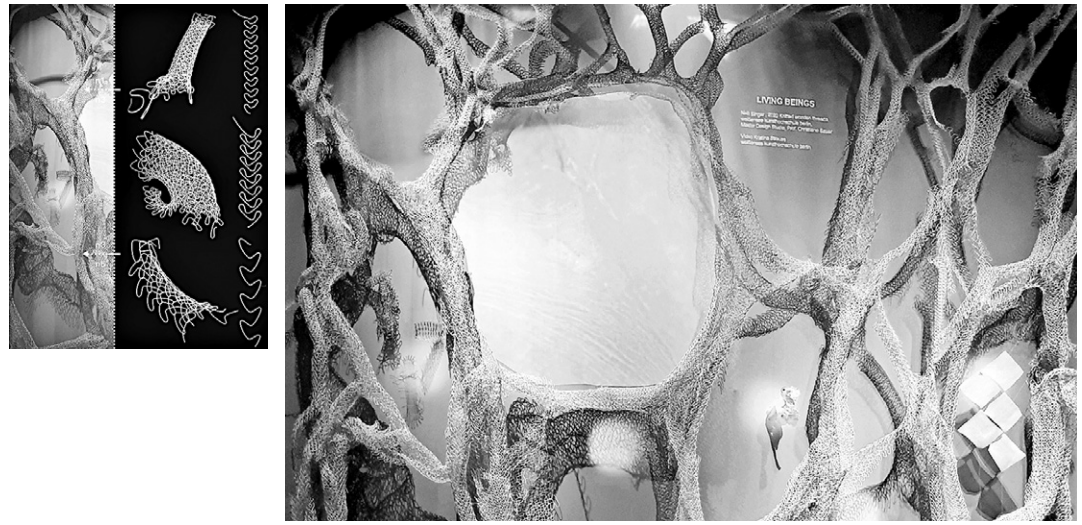


Fig. 7: The structured material: higher pattern densities or knit resolution in the upper area, and lower towards the bottom reinforces the large hanging structure, made using mainly median loop size (a). The overall structure explores the structures of biofilm by expanding it to human scale (b)

The *Active Curtain Project* is not a passive surface but an active spatial structure, echoing cell membranes and bacterial biofilms (fig. 7). With my background in lightweight structures and spatial textiles, Nelli Singer's focus on tacit knowledge and climate-sensitive textiles, and Daniel Suárez's interest in augmented knitting in architecture, we developed a warp-knitting-based material system.

> They are practically everywhere: huge colonies of mucus-secreting bacteria that build bacterial cities on a microscale. (Serra & Hengge 2019)

While biological tissues act as micro-environments of interacting forces, architecture introduces gravity. The material is structured:

a pattern with higher densities is used in the upper area in order to stabilize the large structure and to span the two-meter-wide gap for a video projection surface (fig. 7). Branching principles from trees, studied by material scientist Michaela Eder, with specific fiber orientation and higher fiber density in reaction wood, are translated into structured material—using the higher density knit for branching reinforcement (fig. 8). Microscopic images from the Department of Microbiology at HU Berlin and the Max Planck Institute visualized this research, revealing dimensions otherwise imperceptible. → Intermezzo 3, 202

The perceivable porosity of these enlarged textile methods allows us to imagine material on the microscale as part of our environment. In order to physically model MoA member and mathematician Myfanwy Evans's adaptive mathematical models of organic bulk tissues, bridging mathematics with biology, physics, and physiology, led to choosing rattan (and later willow) as material for modelling. These organic long fiber-based liane and branches are bendable yet stable, suitable for adaptive complex geometries involved. While engaging with research findings from the natural sciences I uncovered that digital and computational methodologies for tracing filamentous networks are applied across radically different scales and ontologies. From microscopic biofilms to cosmic filaments, these networks—sparse or dense, bent or straight—reveal a shared structural logic, bridging disciplines and dimensions.

Structural Textiles—Plektonik

The architectural research into self-supporting material systems and planetary resources, *Structural Textiles—Plektonik*, made from fast-growing woody plants like rattan and willow (rather than timber), became both exhibit and an apparatus for exploring the relations and processes during the exhibition. The research, presented at international textile,[11] engineering, and architectural conferences, as well in workshops with the public, also contributed to exhibiting as a research method.

The transdisciplinary project—collaborating with architects, textile designers, microbiologists, and material scientists—in the frame of *Stretching Materialities* explored how exhibiting can be employed as a research method in regenerative architectural design and cohabitation. *Structural Textiles—Plektonik* translates the textile techniques of warp knitting to an architectural scale and recognizes the loop as the »building block.« In warp knitting, unlike in weaving, where the weft thread interlocks between the warps, the warp »yarn« is pre-formed into a continuous looping element, allowing the loops of neighboring warps to interlock. In contrast to classical weft knitting with a single yarn forming consequent interlocked rows, this method has multiple warp yarns. Drawing from Deleuze's comparison of weaving and knitting, it enables the creation of an endless, smooth surface.

11 Aachen-Dresden-Denkendorf International Textile Conference (ADD-ITC) 2023; XI International Conference on Textile Composites and Inflatable Structures 2023—Structural Membranes; UIA World Congress of Architects, Copenhagen 2023

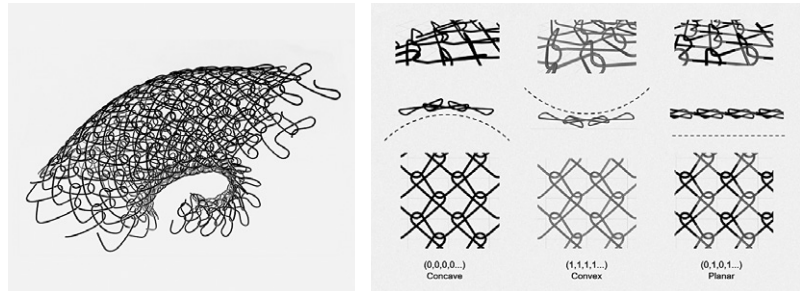


Fig. 8: Different loop sizes can reinforce the form (a). The direction in which one loop interlocks with its neighbor—either from above or below—determines concave, convex, or flat surface continuation (b)

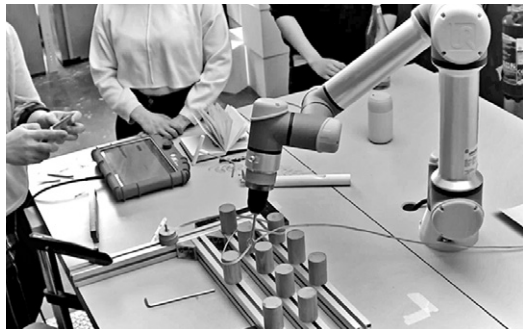
The direction in which one loop interlocks with its neighbor—either from above or below—determines the specific order of the loop, producing either a concave or convex surface (fig. 8b). This process can be efficiently coded using binary code, allowing for the programming of surfaces into particular forms. Combining this ability with different loop sizes enables the creation of complex surfaces (fig. 8a).

This research focused on *active yarns*—filaments and techniques that store elastic energy, such as willow, rattan, and even metal wires. Willow and rattan exhibit bendability and formability due to their filament structures. Unlike timber, plant fibers like willow twigs and rattan palms (liane) are elastic and hygromorphic, gaining plasticity after water absorption and maintaining their looped form after drying. These filament properties impart stability on the fabric itself. Active yarns are continuous strands that inherit the elastic properties of resilient, plant-based filaments of finite length. The continuity of plant-based yarn can be achieved by interlocking preformed filaments or binding them together. The filaments are entangled using a warp-knitting technique, with varying loop sizes determining the structure's strength and stability.

During the course of *Stretching Materialities*, we developed continuous active yarns by binding willow twigs with softer materials such as flax, wooden wool, and sheep wool using Kemafil® technology from the Saxonian Textile Research Institute STFI.

12 http://www.baukunster-finden.org/en/research/projects/tera-x-braided-wood

The self-similar model was used to create hybrid yarns as we replicated the geometry of the rattan and willow cross-sections and variated it for machine feeding. Different fittings were developed and used for producing continuous hybrid yarns. The continuity enabled the use of otherwise finite wooden twigs for the large coarse warp machines. Thus, the result can be recognized as a filament, defined as an elongated fiber, usually used for 3D print technology. Industrial yarn-making is also human filamentation of matter. The novel research introduced wood to the textile industry, and we see the research going in this direction.[12] This resulted in the creation of preformed textile elements up to one meter wide and twenty-five meter-long in size. The innovation to »build by looping« and (warp) knit hybrid active yarns, rather than stacking blocks (interlocking loops, or as Ingold proposes, knotting), opens new possibilities for architectural scales.



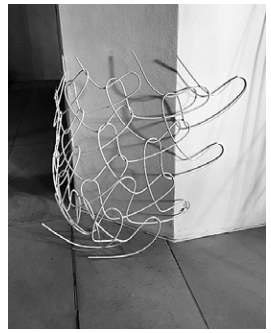


Fig. 9: Digital fabrication—preforming willow splints and rattan. Trial error studies at Weißensee School of Art and Design Berlin, Bauhaus 4.0 (a) contouring walls of TA T (b)

A digital twin was developed through various parametric models for local and global topology. To explore automation in robot-aided fabrication, a method that also serves analytical purposes, we created a script (fig. 9). The textile space became accessible in virtual reality in the interactive exhibition *Stretching Materialities* at TA T Berlin. → Stretching Virtuality

Willow exhibits mechanical and thermal properties ideal for reinforcement and is biodegradable, low-cost, and effective in remediating polluted water and soil. This knitted structure is envisioned as a potential fibrous scaffold for additive techniques, such as concrete or earth, where plant filaments are traditionally used. This scaffold facilitates growth and can support biofilms, such as bacteria or fungi mycelium. The varying porosity and densities achievable through knitting techniques allow the structure to function as a filtering and harvesting spatial membrane—for light, sound, and gaze, and, with the biofilm layer, also for water and air.

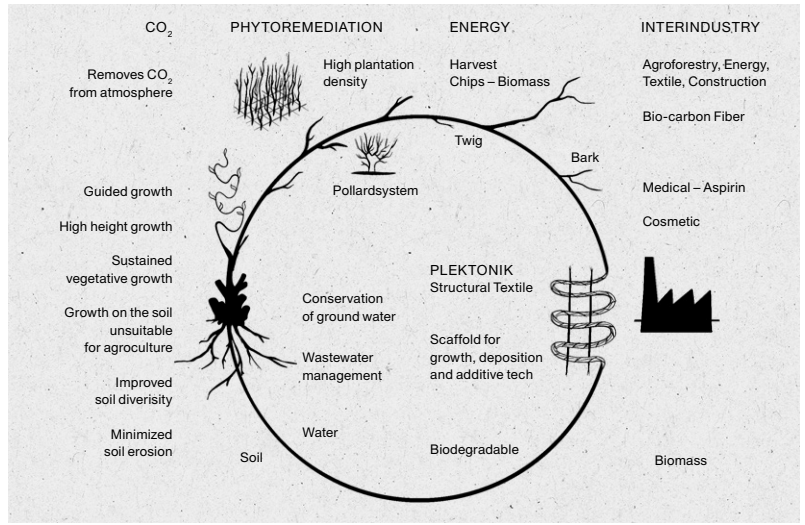


Fig. 10: Circular culture, looping economy—bio-materials connect industries and organisms with landscapes, waters, and soils

These materials are classified as Non-Timber Forest Products (NTFPs), and locally grown willow branches are residuals from the aspirin and cosmetic industries, which only use the bark (fig. 10). The project took a step towards a post-waste society, where not only timber but also small-diameter willow branches are considered valuable resources for architecture, while exploring how non-uniform agroforestry »residuals« and also »social residuals,« such as textiles and plastics, can be redefined and certified within the circular or looping economy and construction.

STRETCHING MATERIALITIES… AND SPATIALITIES

The initial concept for the *Stretching Materialities* exhibition was not to add exhibits. Instead, the goal was to create a mise-en-scène that reveals the exhibition space in the former veterinary anatomical theater and to exhibit processes as a »space-matter anatomy theater.« This shift from displaying objects to research as a staging process emphasizes the active, performative nature of matter and space. It is through a single filamentous hypha that symbiotic lichens penetrate both: stone and air, branching their existence, totaling and metabolizing between environments. The plaited prototypes are not envisioned as objects but as tools, apparatuses for drawing attention and investigating processual relations of matter and void, materiality and spatiality, bodies and spaces.

Besides clothing, transporting, and containing, textile techniques such as netting are used vastly for soil, surface, material, and structural reinforcement, like plaster and concrete, or lightweight elements from train parts to wind turbines. Like technology, architectural textiles are »present-at-hand« (*vorhanden*)– invisible to us in plain sight, an affordance taken for granted, much like the ground, sound, and air (McLuhan 1967, 165).

Once we entered the exhibition building, we would first notice human bodies: researchers, mediators, front desk employees–each engaged in the labor of the exhibition. Yet, as we engaged more deeply with the exhibition, we began to become aware of more-than-human actors. The space revealed the acting bodies of stones, plants, dust particles. The exhibition showed that these hidden processes–matter in motion, interacting materials–were always performing, even without an audience. Drawing on Rancière's *Emancipated Spectator* (2009), we asked: is there a theater without a spectator? The exhibition challenged passive spectatorship, separated from both action and knowledge; the spectator became an active participant through engagement with the processes on display. The exhibition needed the emancipated spectator to be complete, fostering the way of »how to pay attention,« as Isabelle Stengers (2013) proposes.

→ Intermezzo 3, 198

Where Do Architectures and Bodies End and the Exhibits Begin? Theater of Cytoskeletons, Exoskeletons, Biofilm Anatomy

Made from peeled willow and revealing a golden shimmer, the prototypes were in constant iteration during the exhibition, appearing as skeletons of strange »plant animals« exhibited in open showcases–sometimes crawling out. ❑ Exhibition, fig. 10, 132 Produced for architectural research, they were positioned to resemble an anatomical study collection. The shape of the of the loop, the way it bends is unique to the material and method, and it makes willow unrecognizable while still familiar. With their rhythmic repetitions, the prototypes were reminiscent of structures from the animal and insect world–spines and exoskeletons.

During my research on industrially bent wood I found that the measurement for elasticity, the young modulus essential for estimating how much a certain material will deform under a given load, and how much energy it will store or release, is the same for human tendons and willow trees, bones, and oak trees. To be processed in the warp and knitting machine, yarns need a certain elasticity, a young modulus threshold.

In the first showcase, industrial spacer textiles were translated into knitted willow samples at the scale of architectural elements–walls, floors, or ceilings (fig. 12). ❑ Process, fig. 19a, 280 Previous research on spacer textiles at Frankfurt University of Applied Science explored the void–the space between two interconnected textile layers–as a literal material layer and spatial affordance. *Spacer* fabrics are manufactured textiles in which two outer fabric layers are connected by a layer of pile threads that space them, hold them apart (fig. 2c). This textile space is the special feature of these structures. They are breathable, used for cushioning–negotiations between things and bodies–and as textile reinforcement for lightweight elements. In architecture, they have the potential to perform not only as thermo-regulative insulation membranes or formwork but also as filters and harvesters for air, heat, atmospheric water, and electromagnetic waves, as well as scaffolds for biological growth.

The use of different materials–flexible willow shives and stable willow branches–programs the elasticity and stability of a structure, ranging from flexible and responsive to structurally rigid and solid, and from comfortably smooth to sharp and striated. One can feel and compare the energy stored in these knitted spatial trusses.

These prototypes were models for the layered architectural membrane, fabricated with the warp knitting technique. They too were skeletons–reminiscent of enlarged fragments of layered plasma membrane and cytoskeleton. The structure of the cell membrane as a model of relational individuation and semi-permeability was found in a layered spacer textile.

❑ Process, fig. 19c, 280

Gilbert Simondon also recognizes the membrane as a border between temporalities, as Anne Sauvagnargues explains:

> The polarization of the membrane characterizes the living; it is not only topological and spatial, but chronogenetic, productive of time. The present emerges on the membrane's exterior; it catalyzes action and intervenes on the reality to come [à *venir*], however beneficent or detrimental this reality may be. The future [*avenir*] depends on action and is split between favorable and unfavorable, useful and harmful. (Sauvagnargues & Roffe 2012, 57–70)

Biologist Harold Morowitz developed a detailed scenario for the origin of life, a prebiotic evolution in which the formation of membrane-bounded vesicles in the primeval oceans created two distinct environments—an outside and an inside—in which compositional differences could develop. As membranes grew, they eventually split into smaller vesicles. Semi-permeable membranes allow energy and matter to flow through, including chromophores that absorb sunlight to generate electric potentials. This energy conversion process may have driven growth and replication, offering a model for life's origins (Morowitz 1968). The in-between space where the filtering process takes place evokes the spatiality of the border—a liminal space. Not a mere surface, it is a space that affords communication between regions of differing intensities and temporalities—interior and exterior, body and space, matter and environment.

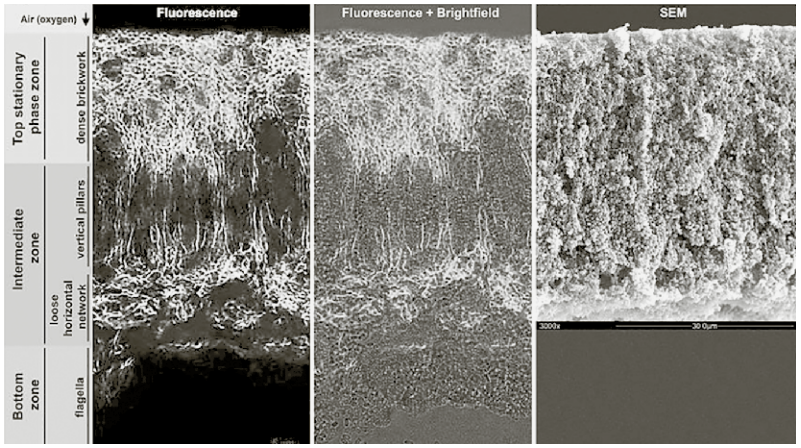


Fig. 11: The cross section of bacterial biofilm cellulose shows two interconnected layers and similarity to spacer textile (a), discussed with microbiologist Regine Hengge (b). On the macroscale, biofilm filters the light of the exhibiton showcase (c)

Moreover, the concept of tubular filaments and microfibrils derived from cell membrane structure is seen to show morphogenic potential. These semi-permeable spatial textiles open up the space for intertwining inside and outside, human and more-than-human habitat. The membrane—as defined by the cell membrane as a semi-permeable space of exchange and flow—is not merely a surface but a space and a state. → Intermezzo 4, 247

While engaging with the research on bacterial cellulose, the result of bacterial filamentation, I also recognized the layered membrane in the cross section of filamentous bacterial biofilm. What appears as a thin layer is actually interconnected twofold, bilayered fabric, a filamentous membrane on a microscopic scale (fig. 11). With support from Regine Hengge and Michaela Eder, these findings were shown at the Biomimetic conference. I placed

the samples with bacterial biofilm growing on the lignin-cellulose rattan on the built-in light fittings of the exhibition showcase. With their specific materiality, they filter the exhibition lighting inside the showcase. During the course of the exhibition, further multilayered samples were produced with Skandar Hathroubi at the Microbiology department at Humboldt Universität zu Berlin. Considering that research into bacterial cellulose is engaging with a single surface, the multilayered samples presented us with a novel finding (fig. 11).

13 Travelling exhibition *Critical Zones. In Search of a Common Ground*, first exhibited at ZKM | Center for Art and Media Karlsruhe, Germany (2020–2022).

Fig. 12: Display cases with continuously developing willow yarns

Latour, for the exhibition *Critical Zones*,[13] defined the thin layer where most of planetary life occurs as a biofilm, borrowing terms from biology for the morphogenetic propagation of microorganisms: »It is no more than a varnish, a thin mat, a film, a bio-film.« (Latour 2020) Further, to address the interactivities of trans-scalar environments, he implies the human/animal scale of the membrane, the skin of planet Earth: »We have to imagine it as a skin, the skin of the Earth, sensitive, complex, ticklish, reactive. That's where we all live—cells, plants, bugs, beasts, and people.«

Wearing Baskets

The scale and the resolution of the knit made the samples suitable for wearing. The second display case in the exhibition space became a fundus, a wardrobe of all architectural samples that we were wearing during the research. ❑ Process, fig. 2, 266 The research examined clothing, architectures, and technology as homeostatic conservation layers, and the extended endothermic

14 등등거리 (Deung Deung Geo Ri)

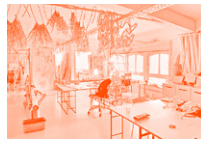
metabolism of the human body. The extension of the human body through woven, constructed, and networked materials signifies a profound shift in the biological definition of humans. To observe humans biologically as naked, textile-less beings appears as a fiction of science. The images of uncontacted peoples, indigenous tribes that do not want contact with capitalistic society, excite us, since they make us think that we, too, can exist as organisms without or with minimal extensions (fig. 13).

A key question arose in our pursuit of active architectures: how can our external membranes be designed as extensions of living systems? Variable permeability properties enable active mediation between internal and external environments. Textile knowledge lies in understanding how to contain matter in different states: regulating body climates, programming materials to alternate between solid and flexible, or adapting porosity. The structural textile prototypes evoked the intricacy and precision of anatomical samples. → Stretching Senses, 328

Fig. 13: Networks and membranes: a human–extended organism

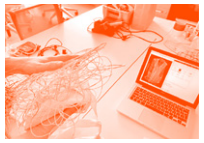
Animal-built structures are properly considered organs of physiology, in principle not different from and just as much a part of the organisms that are more conventionally understood as organs. In their edited volume *Modell Hütte,* Karin Krauthausen and Rebekka Ladewig (2021) included a text by Turner about the *Extended Organism*, suggesting the hut is a human extension. In a chapter on filtering architecture in the same volume, Susanne Jany and Khashayar Razghandi make an argument for the biological approach to architectural and media practices, comparing the filtering organism of *Tunicata* to experimental projects from pneumatic lightweight architecture that explore the relation with the environment. »The notion of the *extended organism* situates such filtering architectures within a biological framework, arguing for a symbiotic view of spatial and material practices.« (Jany & Razghandi 2021, 456) On the one hand, we have a layered, semi-permeable membrane for individuation of processes, on the other, a membrane as filtering extended organism, which is how we define our relation to the environment.

Spending time in the same space with other disciplines in MoA's Experimental Lab was knowledge-productive. ❑ Process, fig. 6, 269 My models with double layered spatially crocheted rattan twigs (fig. 14a) reminded anthropologist and designer Yoonha Kim of traditional undergarments (Deung Deung Geo Ri).[14]



These have a solely climatic function—to secure space for separating and cooling the sweating body from the silk *hanbok*. It is made by splitting wisteria trunks into thin pieces and weaving them into a vest shape.

This is a ground-breaking revelation, since it confirms several arguments: wearing baskets—textile wooden »yarns«—stands in a human tradition, climate can be regulated on the scale of the body space, and the same techniques can be used for wearing and building. ❑ Process, fig. 3, 266 This important piece of traditional clothing together with the *tantoshi* (worn on the arm) is exhibited alongside the *hanbok* of the *Virtual Sensing Knife* project as an introduction to the research on architectural prototypes (fig. 14b). Today, this streetwear can be seen only in the museum. It is revived in the exhibition to enable a rethinking of the climatic negotiations between the body and the environment. → Stretching Senses, 318



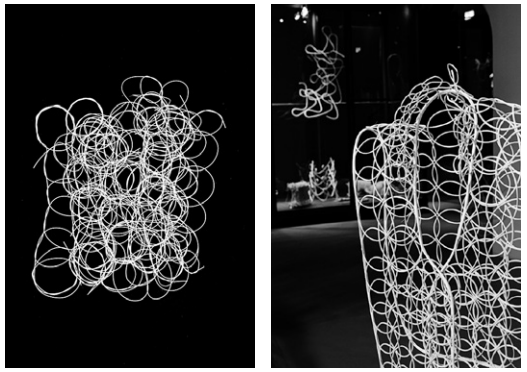


Fig. 14: Negotiating climates, bodies and architectures: spacer crochet model (a) and traditional climate regulating vest Deung Deung Geo Ri (b)

Film director and musician Leila Albayaty explored the space using her voice, preferring not to appear as human but to *become a tree*. Depriving herself of bodily appearance, she allowed her voice to resonate through the space, amplifying hidden material processes. By transforming sonic reflection into emotional and spatial affect, she explored layers of identity, subjectivity, and more-than-human polyphony. Singing along the curved walls of TA T, she activated a phenomenon where sound waves, through acoustic focusing, concentrated at focal points—allowing unexpected clarity and transmission across distance.

Metabolizing the Exhibition Space

With the developed loop-based technique, complex geometrical surfaces can be fitted. Like crochet, knitting can render complex forms and geometries. The adaptive objects

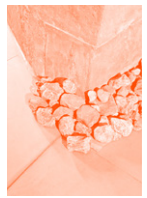
15 The essay was written for the Hella Jongerius exhibition *Space Loom #1* (2022).

were shaped and positioned to trace, the intricate forms of the exhibition space: along the edges of the arch, around the column, and smoothing the corners and contours. They served as an apparatus for tracking and tracing architectures and bodies. Much like symbiotic lichens growing on stones, metabolizing both the exhibition walls and space, knitted prototypes »stretched« the walls into open space, acting as extensions—as weathering.

In their essay *Event of the Fiber* (2022),[15] MoA members Regine Hengge and Karin Krauthausen describe textile spatiality as a possible human-made extended organism (also drawing on Turner):

> Fibers are delicate lightweights with vast surfaces—in relation to their volume—that can simultaneously enter into multiple weak interactions. These interactions result in strong overall cohesion, while still allowing for local reconfiguration or loosening without the entire structure tearing or collapsing. This intricate, intertwined world of fibers forms soft, elastic, dynamically changeable, yet stable structures—the very kind needed by active, growing, living systems, not only inside their cells and tissues but also at their flexibly expandable interfaces and protective envelopes, where controlled communication with their environment occurs. (Hengge & Krauthausen 2022, 4)

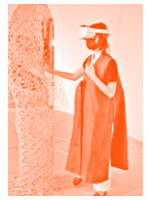
Ultra-light yet stable, the adaptive objects were scattered throughout the exhibition space. The porous structures, changing the contours of the actual walls of TA T depending on the light, were at times barely visible. Some appeared as shed exoskeletons or skins of unknown insects or animals. Larger samples, placed in open showcases, were occasionally worn by visitors. These prototypes made visible the metabolic processes occurring between bodies, organisms, the exhibition space, and the mineral-based architectural wall. The wall, apparently built with large red limestone, is itself undergoing weathering—its surface deliberately arranged to appear as spalling, crumbling, and eroding—stripped of its representational role. ❑ Exhibition, fig. 1, 121



> It is not the boundary itself that makes an organism distinctive, but what that boundary does. In other words, the boundary is not a thing; it is a process, conferring upon the organism. (Turner 2002, 9)

An organism's persistence relies on the tangible boundary that separates it from its environment. Though it may seem solid, an organism's outermost boundary is, in fact, highly permeable, allowing a continuous flow of matter and energy. This new perspective on the living world helps us view animal-built structures that perform physiological work, capturing and channeling chemical and physical energy, as extensions of living bodies.

Through computation and digital modeling, different filamentous structures unify processes occurring at various scales into a shared realm. Bacterial filamentation—similar to the silk-spinning of spiders and moths—is a self-metabolizing process through which an extended organism creates its own environment. Human filamentation similarly engages with textile structures, networks, fibers, filaments, branches, beams, pipes, and cables. The exhibition *Stretching Materialities* explored the filamentous »extended organism« applied to architecture and human-made structures. Turner's argument of the extended organism, when applied to human »space-making« as thermodynamic continuity, helps us understand our inseparable connection to our environment. ❑ Exhibition, fig. 25, 143



At stake is the »notion of self,« where the self implies a symbiotic collective. This relationship between self and collective highlights how individual organisms are not isolated entities but part of a larger environment. It mirrors the symbiotic relationships in filamentous structures—interacting not only with other organisms but with materials, objects, and spaces.

Exhibiting, weaving, and architecture, then, can be seen as forms of »human filamentation«—an extension into the delicate, thin fabric, the biofilm of planetary life, as Latour calls it. The digitalization of filamentous processes contributes to remediation, care, and monitoring, thus redefining architecture and other spatial practices. Sensor-embedded textile systems, for instance, can monitor air quality or humidity levels in real-time, allowing adaptive responses to environmental changes and promoting sustainable building practices. ❑ Exhibition, fig. 2, 122 These sensitive wooden filaments react to humidity as shown in the project *Living Beings* by Nelli Singer, and act as analog sensors, revealing material activity. In an era where material resources and environmental conditions are changing too rapidly to rely solely on transgenerational knowledge, tracing and monitoring have become essential for learning. This insight blurred the

architectural »edge« of the exhibition space. The display of the object became a negotiation between the exhibit and the architecture itself. The prototypes or meta-types acted as tools for exploring spatial relationships between bodies, materials, and environments (fig. 15).

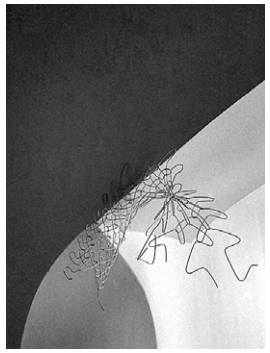
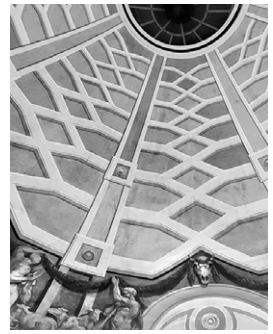


Fig. 15: Structured material is adaptable to the complex surfaces of the TA T building

The rough red stone at the base of the massive arches evokes the Rote Mainsandstein riverbanks. Sourced from the planet's core, this juxtaposition of materials reflects different temporalities—the two-million-year-old origin of the stone versus the building's mere 200-year history—provoking reflection on humanity's connection to the matter used in spatial production. Meeting the exhibition space halfway, the stone pile, designed to appear as eroding, introduced a sense of »strangeness« into the space. It stretched the stone collections of HU, showing the activity of stones and introducing human impact to matter-morphosis. → Stretching Time, 214 What makes a stone collectible, rather than viewing it as simply »material residue« or mere planetary matter? It is through what we discard that we define ourselves. (Calvino 1994) The *Leaking Stones* challenged traditional practices of collecting and conservation, juxtaposing human disruption—bioturbation, extractivism, tectonic altering, mining, and construction. ❑ Exhibition, fig. 1, 121 Interestingly, Berlin's highest elevation is a human-made hill called Arkenberg in Pankow, built by piling up construction debris and surpassing Teufelsberg, which was formed from WWII rubble. Urban tectonics and landscapes are also stretchable. In order to emphasize the finite nature of planetary resources, two meteorites from the Humboldt collection joined the stone exhibit. Shaped by their fall through the atmosphere, these meteorites yet contain the same minerals that are present on planet Earth, symbolizing universal continuity of matter. → Stretching Time, 214

WILLOW REALITY (WR)

The illusionary meshwork-like painting inside TA T's amphitheater dome depicting animal scenes is the historical example of making a collective augmented space for science. The force derived from animal sacrifice, distributed by vulnerable humans and plant garlands, is structural—it symbolically carries the load of the dome over the amphitheater (fig. 16a). Unlike virtual reality (VR), where everyone has their own VR set, this historically painted virtual space high up in the amphitheater is a technology for the collective—designed for a collective experience.



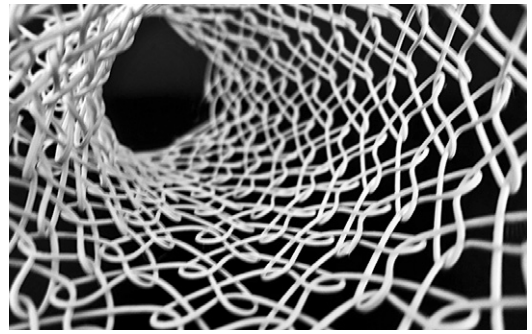


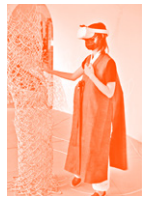
Fig. 16 The illusionary meshwork-like painting inside TA T's amphitheater dome with animal, plant, and human scenes (a) and model for the Haptic Nest (b)

The neoclassical edifice, with its anatomical theater, was an architectural innovation inspired by the veterinary anatomical amphitheaters in Paris and Lyon. Conceived on the verge of the French Revolution and the ideation of a future society, the amphitheater, wooden benches, and laced guards form the perfect globe, which was prominent in visionary architecture by Étienne-Louis Boullée and Claude-Nicolas Ledoux's Palais National. In a text accompanying the exhibition *Making Things Public* (Macdonald & Basu 2007, 105), the authors argue that the single sphere, the dome, the parliament of bodies, exemplified with visionary architectural drawings by Ledoux from the time of the French revolution, should be dissolved.

Space as a collective, as a collection, and as a public entity was examined simultaneously in the exhibition space and in VR. The shared experiences formed an informal collective—an instant community. The act of accessing the *Haptic Nest*, though highly personal, was at the same time public—you were crawling and moving—performing in the exhibition space. In VR, you were aware of other visitors in the VR environment and their movements. Unlike conventional architectural textiles that are in tension or hanging, the self-supporting structure and co-knitted *Haptic Nest* was conceived as an environment to re-enact the interplay of matter, energy, and space for collective imagination. This responsive willow installation, pleated both digitally and physically, formed a trans-digital responsive environment—a spatial, woven nest. Simultaneously accessible in VR, it explored the multi-scale of material porosity (fig. 1, 6–7). Its responsiveness revealed the material driven behavior and allowed us to examine bodily haptics, the notion of ground, and environmental density.

Porosity is measured in nothingness. In architecture, the 60% perforated metal panel or web is »60% nothing.« The void in textile is as essential to the woven structure as the material itself–this void is palpable: »…it's teeming with the full set of possibilities of what may come to be.« (Barad 2007, 354) Therefore, the textile as a technique becomes a tool for exploring spatiality. This duality of the material and the immaterial within a textile serves both as a starting point and a tool for investigation.

In VR, the geometry of the accessible structure appears perfect but rather featureless. The crackling sound of the willow, the force of the twig responding to body weight and pressure, and the texture of the reticulated structure guided the hand to explore. The hesitation in analog explorative movements is different from those in VR. The knitted column was a digital replica of the column in the exhibition space. While the actual structural column is rectangular, clad in wood, it appears rounded. The column exists in several realities: the original structure hidden from view, the representative wooden cladding that makes a hollow sound, the knitted column, and the columns in VR. ❑ Exhibition, fig. 25, 143



Apart from the existing architecture and the leaking stones, the knitted column and *Haptic Nest* were the only constructed spatial elements present in both VR and the exhibition space. → Stretching Virtuality, 83 The aim was a simultaneous experience, a sensorial juxtaposition of the textured objects with the smooth surfaces of the walls and columns. The developed warp knitting method using willow branches resulted in a novel, self-supporting textile structure. The willow structure *Haptic Nest* was designed on a human architectural scale; a fishing trap immersing the visitor, an embodiment apparatus: you could crawl inside or even walk in if you were small, either alone, or with someone else.

From the very beginning of the preparation phase for the exhibition, the space itself provided clues as to how to proceed. The goal was to make an accessible, experiential space and to establish a relationship with the exhibition space. The walls are so thick that their openings create a unique space. It is neither a room nor a wall; it is the space within the wall.

The woven, plaited space afforded by *Haptic Nest* represents an interplay between the material and the immaterial. The porosity became part of the exhibition space, creating a larger void, while the materiality of the plaited willow created a distinct spatiality. Visitors were invited to enter the tubular willow structure; the initial idea was that the feeling should resemble entering the old doorways, designed to bend down

on entry, making an entrance to a space of a different density and intensity readable through bodily movement. This transitional spatiality is reminiscent of biological processes, where the membrane serves as an actual phase, a process of mutual separation and connection.

The other important aspect was to alter the relation to the ground. The ground, like air, is often taken for granted. Altering the ground initiates in the mind-body the process of a reinvestigation of the surroundings. Initially, we envisioned that the whole space would be covered with stones, and the willow ground would be cushioned with structural textile prototypes.

Such cushioning prototypes, with different levels of adaptivity and interaction, from elastic to solid, were exhibited in the display case. ❑ Process, fig. 19, 280 The ground was activated, with one single »structural fold« between the fragile slow body of the visitor and the stone floor of the exhibition space. A soft, pressurized body that should not be punctured, the skin organ as an interface was always extended with wearable textiles, or, if not, aware of its vulnerability from the outside. The fold activates the body to negotiate with the structure. The nest is minimal habitat, a porous niche, an architecture of the in-between, a chronogenetic membrane. → Intermezzo 3, 191

It is a sensible inside-outside, like the experience of touch, a re-learning and sensing self that is perceptible in itself, where the self is extended:

> … the body sensed, and the body sentient is as the obverse and the reverse, or again, as two segments of one sole circular. … Why would the synergy not exist among different organisms, if it is possible within each? Their landscapes interweave, their actions, and their passions exactly fit together: this is possible as soon as we no longer make belongingness to one same »consciousness« the primordial definition of sensibility, and instead understand it as the return of the visible upon itself, a carnal adherence of the sentient to the sensed and of the sensed to the sentient.« (Merleau-Ponty 1968, 138, 142)

The accessible, large *Haptic Nest* engaged the visitor's hands to guide the body into the structure. ❑ Exhibition, fig. 11, 133 The digital model was not identical, addressing the imperfections of

reality—an analog glitch. The apparently infinite digital space allowed a journey through different scales: from the tubular installation, the fiber of the willow branch, to the filament of the lichen on the weathered rock. The experience had a »mise en abyme« or Droste effect—entering a yarn that is knitted.

As part of the exhibition, participants were given two meter long willow branches. ❑ Process, fig. 7, 270 Using the pointed tip to probe floors and walls while placing the broader base to their ears, they engaged in a low-tech yet highly immersive sensory practice. The hollow sap channels of the willow acted as natural acoustic waveguides, transmitting vibrations and amplifying sound—offering an immersive *Willow Reality* in parallel to the VR technology. → Intermezzo 3, 194 The exhibition unfolded as a progression—from vibration and sound to polyphony, and from filament or fiber to textile spatiality. The situated immersive practices—inhabiting textile spatiality, engaging with immersive VR and *Willow Reality*, and participating in collective embodied experience—examined the polyphony of spaces, materials, bodies, and scales, entangling conservation, degrowth, and decay.

Structural Textiles with Nelli Singer and Daniel Suárez

Nelli Singer, Daniel Suárez, and myself reflected on the process of developing the *Structural Textiles* project, a novel post-waste material system that is employed in exhibitions as an architectural research method, bridging microbiology, materials science, design, textiles, and architecture. Textile designer Nelli Singer's *Living Beings* is a thread made of wood that deforms independently and partially in different ways depending on humidity. Only a closer look at the »hydrophobic« properties of these materials made it possible to specifically develop a wooden thread with comparable properties. When entangled, dynamic surfaces or objects can be produced that react interactively to their environment and can perform different movements. The perplexing effect comes from the fact that the created surfaces can move on their own, as if by magic, like animations. Knitted fabrics, which obviously have no central body or control mechanism, seem to temporarily transform into living beings. As an architect and interdisciplinary researcher, Daniel Suárez explores experimental design methods and fabrication processes in architecture. His work bridges human craftsmanship, vernacular design, and digital fabrication through computational tools. Focusing on the interplay of craft, fiber materials, and digital technology, his research examines how digital instructions, geometry, and fabric formation principles inform innovative structural designs.

In order to develop *Structural Textiles*, we also had to consider the aforementioned *Active Curtain* project, where the idea emerged to showcase bacterial and plant cellulose research to represent the interdisciplinary cluster (fig. 7). Petra Blaise's *Inside Outside Studio* was selected with the concept of open, free space by suspending all the exhibits: as dynamic curtains, or mechanized showcases that can be lifted up. The findings from *Active Curtain* were further developed for and during the *Stretching Materialities* exhibition. Transdisciplinary exhibition-making means engaging with research from colleagues across disciplines and their perspectives, forming a thought collective. → Stretching Virtuality, 80 The publicity of exhibiting makes these collectives permeable. Moreover, through reflecting on the process, we diffract (Haraway & Goodeve 1999, 102): embodied social knitting, more-than-human subjectivity, adaptive growth, and reassembling change the notion of materials and spaces, positioning the experiential level as essential to material system research.

Over time, Nelli, Daniel, and I experimented with rattan for larger structures, merging techniques across disciplines—loops, looms, and materials—and eventually created a five by five-meter structure. By scaling up bacterial cellulose architectures and enlarging traditionally small stitches, we opened up new dimensions and perspectives. We integrated findings from Nelli's *Living Beings* project, Daniel's knitting fabrication research, and my warp knitting work from Frankfurt University of Applied Sciences with Claudia Lüling. This integrative approach shaped the branching structure and allowed us to explore bacterial design and the materiality of bendable rattan. The project evolved organically, with each team member contributing complementary skills. While we didn't always know the final outcome, the project grew, showcasing large-scale design and structure.

The shift from small-scale stitches to larger loops significantly changed the structural dynamics. When scaled up, they created a unique architectural impact. This change required us to alter how we connected the tubular yarn structures, resulting in new terminology for the production process. Each structurally

and topologically relevant assembly received a nickname—such as »the elephant« for a directional change in the warp knit. In branching, similar to a tree, the knit resolution was denser, thanks to Michaela Eder's materials science expertise. This not only facilitated communication during decision-making but, in the case of Nelli's project, gave the material system subjectivity, making it »more than human.«

Nelli's *Living Beings* project was also part of the *Stretching Materialities* exhibition. Initially, we hoped to let visitors interact with the cellulose by spraying water to observe its activity, which was instead showcased in a video with images in different scales. Microscopic analysis from researchers at the Max Planck Institute of Colloids and Interfaces allowed viewers to explore the exhibited structures in motion, revealing the swelling behavior of

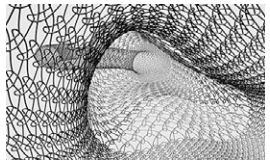


Fig. 17: Like Urban Knitting activism, the large structures call for social knitting (a), Nelli Singer's spatial forming of the *Haptic Nest* (b) in parallel with the digital (c)

the material at a micro level. This connected the larger physical installation to its underlying cellular structure, bridging the material's macroscopic appearance with its microscopic reality. An important aspect of the project was »social knitting,« drawing from bacterial quorum sensing (fig. 17a). The team worked together on a large project, which is typically a machine-driven or individual task. This collaborative effort was especially unique during the pandemic when the team worked in isolation while others stayed home. The large-scale knitting project and hanging structure, a fibrous scaffolding,[16] is denser at the top with intricate branching details to distribute forces. An interesting challenge was how gravity impacted on the structure, requiring adjustments like knitting upside down to prevent breakage. The directionality of warp knitting was crucial for ensuring stability.

Flexibility, adaptability, and reversibility are key features of the system. We designed the system to be adaptable, allowing us to pivot it and introduce new structures or fields. It's amazing that we can potentially re-conform (a modular structure has the proportion of optimal conformity) the structure without cutting or destroying it. The ability to reconfigure is an important feature (fig. 17b). By unlocking connections

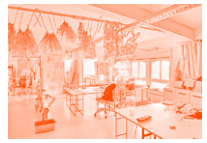
16 Scaffolding is also the extracellular structure of bacterial biofilm.

between the loops and redirecting them, we were able to create entirely different forms. Even after five years, the structures remain in good shape without the need for maintenance, meeting the necessary period for material approval. In addition, we can now also see that the strained part »took form« and can hardly be reassembled without soaking and drying again.

The method of exhibition as research became central to our process. It allowed us to not only exhibit outcomes but also the journey of research itself. Through the *Stretching Materialities* exhibition, we were able to continue developing our material system, and the exhibition context provided an opportunity to scale up and explore new structures. Not all textile designers are open to stepping beyond machine-scaled, independently produced textiles, but Nelli was enthusiastic about engaging with this broader perspective.

Choosing willow was a natural decision, reflecting our holistic approach to materials. Elena Eulitz, who works with elasticity structurally introduced us to the material, and I conducted extensive research on rattan sourcing. Despite my efforts, including contacting suppliers, I was never able to fully determine the origins of the materials. Michaela Eder suggested I would need to live where the materials grow in order to truly understand them.

While working in MoA's Experimental Zone, an open work space where the designers with practice-based research also conducted experiments and produced prototypes, surrounded by these structures, we developed a sense of what it meant to inhabit them. ❑ Process, fig. 6, 269 The exhibitions at Humboldt Forum and TA T provided a context to expand our research in ways we might not have considered otherwise. Daniel summed it up:



> Considering the entire production sequence we achieved for the exhibition, it's impressive. We developed this system in just a few months, while our own research might have taken two to three years. Each exhibition gave us the opportunity to explore different aspects. Usually, research has deadlines, but the exhibition really pushed our limits. Preparing for the TA T exhibition in six months was a challenge, but it sparked productivity. We didn't rush things just because the opening was approaching. Ultimately, we created something meaningful under pressure.

I remember early models of what we called »active« prototypes, created with wool and flax materials I found at a local market. Initially, I thought we'd just need to produce samples for industrial prototyping in Chemnitz, but the pandemic changed everything. Most of our work was done manually, offering a new experience. Nelli added:

> With every material and scale, the knowledge expands. Shifting to willow was a completely new challenge. While working with laser-cut wood and rattan was easier, willow has a character of its own—it tries to return to its original shape, which makes it tricky to work with. The sound of the material was also different. Rattan is silent, but willow cracks, revealing the tension within, adding a whole new sensory layer. It was almost as though the willow was speaking to us!

We also discovered the special properties of water after soaking the willow, which helps plant rooting—adding another dimension to how we interacted with the material. In TA T's special eighteenth century vaults, we were able to negotiate the architecture of the exhibition space with our material systems. We produced prototypes that reflected the space's geometry beautifully. → Stretching Practices, 29

The installation felt immersive compared to the previous exhibit, *Active Curtain Project* at Humboldt Forum, which had a more contemplative atmosphere. Visitors interacted with the structure differently; it felt more alive. Although the earlier project focused on living organisms and movement, it didn't have the same dynamic presence. We managed to create structures that were both accessible and resilient. Nelli took the challenge of ceiling loads seriously—the structure can hold up to 300 kilos.

Meanwhile, Nelli's experience in the automotive industry revealed that advancements have been made in textile machinery, highlighting the potential and limitations of weft flat knitting, circular knitting, and weaving for architectural applications. While weft and warp knitting have shown flexibility, particularly in spacer textiles, warp knitting machines have lagged behind in innovation. Spacer textiles, reliant on stable materials, show promise in adapting warp knitting processes to thicker materials like willow, aligning with architectural scales. The challenge is overcoming existing machinery constraints to unlock new material and process possibilities. Exhibition as an architectural research method in cohabitation, *Structural Textiles* examined the very structure of architecture and the construction industry, resources, materials, spaces, and practices. Exhibition making, creating a continuous *warped space* for different actors, made the holistic approach possible, which is needed to address the very structure of the discipline. Beginning during the exhibition runtime, the project *Myko-Plektonik* with Vera Meyer and Bertram Schmidt from the department of Applied and Molecular Microbiology at Technische Universität Berlin, and architect Dimitra Almpani-Lekka explores *Structural Textiles* as scaffold for growth of filamentous fungi, *Fomes fomentarius*, sourced locally.

Fig. 18: *Myko–Plektonik* explores the filamentous fungal growth on *Structural Textiles*

Expanding the influence of the Bauhaus textile researchers as well as artists engaged in filamentous architectures, digital fabrication, and lightweight structures further opened up the possible capacity of these structures toward a new transdisciplinary (post-)structuralism that Wolfgang Schäffner (2016) calls »supple structuralism.« The textile logics encompassing digital ecologies and textuality contribute to relational and processual materiality.

Returning to Rancière and the question if there is a theater without a spectator, the proposed exhibition concept of »doing nothing« comes from a rejection of extractivist architecture and a call for degrowth in the economy and thus in architecture and construction. More precisely, it derives from the architects Lacaton & Vassal's concept for renovating a large exhibition space, the Palais des Tokyo in Paris, for which they won an architectural competition by leaving the building as it was, without doing anything. Yet, »doing nothing,« according to Lacaton, is a very complex and elaborate project.[17] Passivity, in line with *The Limits to Growth* (Club of Rome 1972), is in itself a lot of work:

17 https://untappedjournal.com/stories/edwin-heathcote-architecture-of-doing-nothing

the capacity to imagine the future we want is our main task. In theory, these processes take place even if they are not observed.

This shift from displaying objects to research as a staging process emphasizes the active, performative nature of matter and space. The exhibition, however, intended to shift the visitor's role from a distant observer to an active participant, out of the desire to create communities, through collectives, through shared experiences. The word drama originates from the Greek word *drama*, meaning action. Active matter can be read as a kind of »matter drama.« Rather than a passive experience, the exhibition invited action in front of living bodies, offering visitors the chance to become part of the performative processes. We can see here the social role of exhibiting and its potential as an empowering practice. → Intermezzo 4, 257

The activation of participants took place in two stages: first, through the strangeness and enigma of the exhibited processes, which prompted visitors to become amateur scientists, searching for clues and understanding. Second, they were drawn into action by the performative energy of the exhibition. This created an exchange of energy–vital, metabolic: the exhibition needed the participants in order to complete the hidden theater of matter.

As a research method, exhibiting situated broader inquiries into »active matter« by examining processes across multiple temporal and spatial scales through the lens of »place« or »zone.« It engaged with collections, data, locations, networks, climate, and more by including different places that are inherently connected to exhibition making–from the Max Planck Institute for Colloids and Interfaces, the fields where willow is grown, to the cables on the bottom of the ocean, and computing servers where exhibition data are scattered and stored. These places radiated and filamented into zones, fields, and clouds and interacted with other zones into networks and climates. Polyphony, much like Timothy Morton's (2013) concept of hyperobjects, → Stretching Practices, 25 → Stretching Senses, 309 offers a conceptual framework to address the complexity of changes in material and spatial resources that impact biological diversity and human life. Architecture today operates not only at visible scales of spectacle but also within metabolic, nano, and hyper scales–such as weathering, digital ecologies, economy, and climate.

As an interdisciplinary practice, the exhibition brought together scientists, designers, and humanities scholars, encouraging them to expand their research questions and foster clear communication across disciplines and with the public. This approach emerged from a critique of institutional museums, shifting the focus from presenting static knowledge to questioning: how do we come to know something? Engagement with social and scientific practices is addressing the quest by Isabelle Stengers for a better science. Remediation–in the media studies sense of re-mediation with new media technologies–is combined with remediation in the sense of healing soil and landscapes used in ecological studies. Both terms met in the framework of the exhibition. Thus curating, or healing, received another meaning in the context of regenerative design.

The accessibility of exhibition spaces and collaboration with curators shaped the scope of research conducted during the exhibition period. Less accessible spaces for experimentation resulted in limited spatial interventions, with research primarily conducted during the preparation phase (e.g., the *Active Curtain Project*), encouraging more contemplative interactions with the research material. More accessible spaces enabled ongoing research throughout the exhibition period, allowing for iterative changes and developments (e.g., *Stretching Materialities*). Concrete physical engagement with objects and spaces, combined with spatial interventions, fostered bodily engagement and immersion, creating opportunities for embodied knowledge. Audience interaction was essential for completing the exhibition, as public engagement could not be avoided or ignored, and instead contributed to the exhibition. These shared experiences built an informal community and contributed to a collective knowledge and »critical mass« towards new cultures of material through publicity.

Curated public engagement provided valuable feedback, enriching the research process. Prolonged or repetitive engagement with an exhibition, or »inhabiting,« was able to transform passive observation into active participation. Exhibitions hold the potential to generate a »research surplus;« through their creation, »this research surplus does not only concern how much we know, but also involves different ways of knowing« (Bjerregaard 2020). This method remains open and adaptable, embracing unpredictability as part of its process–*exhibiting in the making*. By collaborating with artists, traditional craftspeople, and industry, and by showcasing processes, this approach incorporated diverse ways of knowing, interconnecting various ecologies of knowledge.

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