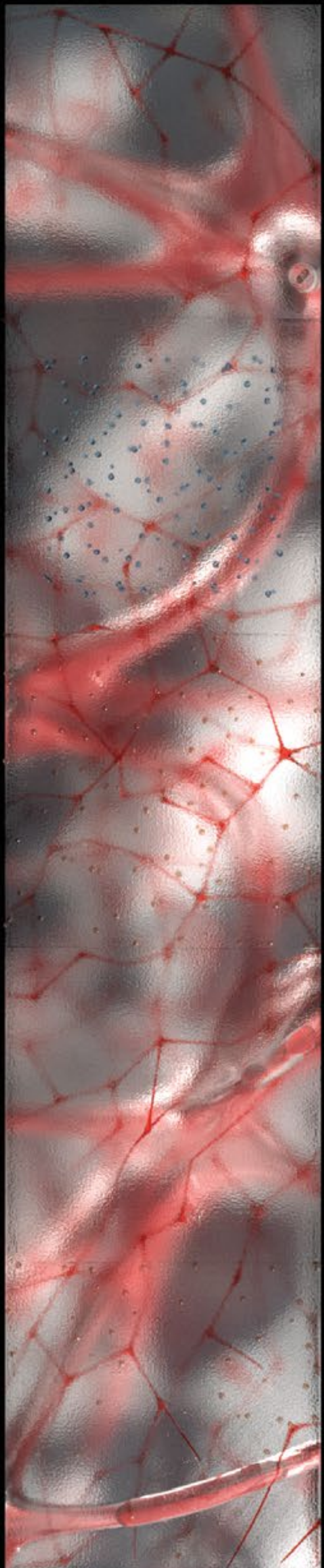


MORPHO GENESIS+

Growing Futures in Post-Natural Cities.

Syracuse University SOA
ARC 498/698 DIRECTED RESEARCH 2025'
ADAPTIVE FAÇADE RESEARCH
w/ PROF. DAEKWON PARK

“

MORPHOGENESIS is a biological process through which forms are generated based upon genetic and environmental interactions. In the exploration of hybridized material research in response to extreme climatic conditions, ***MORPHOGENESIS*** seeks to describe the fusion occurring between natural growth patterns with artificial fabrication methods, leading to adaptable, efficient, and bio mimetic hybridizations. This project is inspired by several relevant case studies of hybridization that occurs within nature, humans, and architecture, proving the added applicability of a hybridized facade can be beneficial. Through a research scope by collaborate with a overgrowth of nature, sci-fi narrative, ***MORPHOGENESIS*** argues to be an experimental habitable solution dependent on environmental and situational factors.

”

CONTENT

\+ **RESEARCH**

01

+ *SKIN TECTONICS*

In the natural environment, **HYBRIDIZED SYSTEMS** can be seen in **ANIMAL SKINS**.

Through analyzing different **ANIMAL SKIN TECTONICS** such as an armored skin, camouflage skin, mammalian skin, etc., each performs their specific functions and control the environment within the animals to protect the organism from the outside.

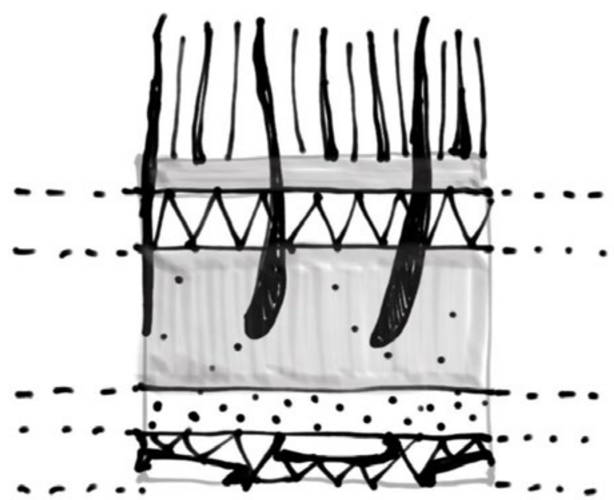
01

LAND

PROTECTION

02

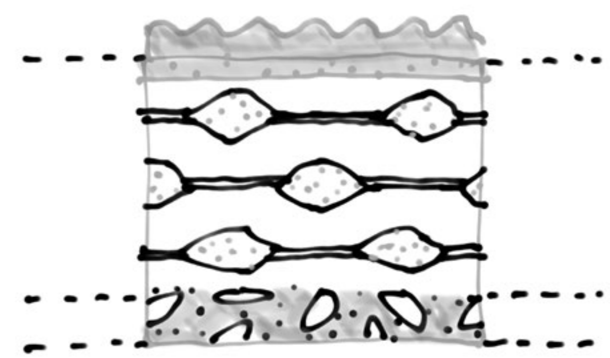
POLAR

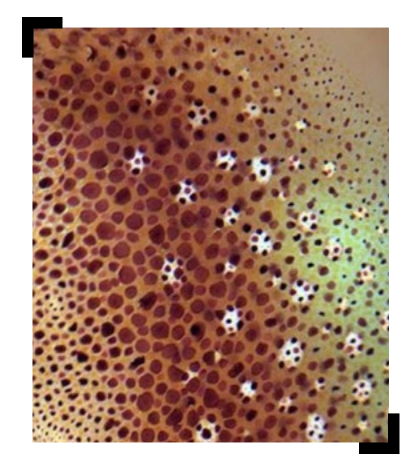


THERMAL CONTROL

03

OCEAN

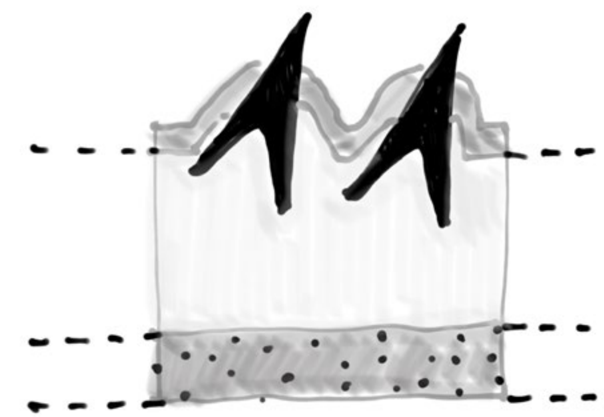


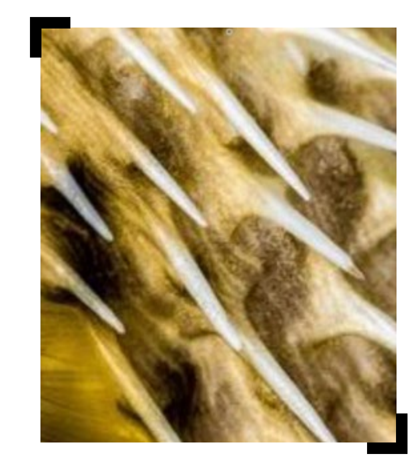


CAMOUFLAGE

04

LAKE





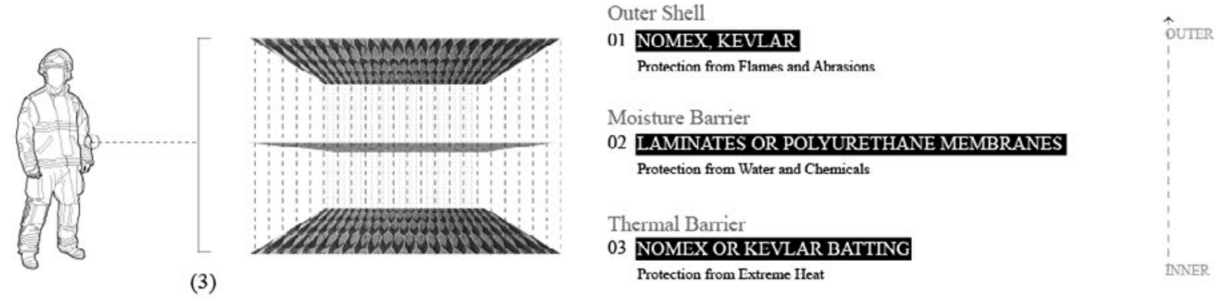
PROTECTION

+ *HIGH PERFORMANCE SUITS*

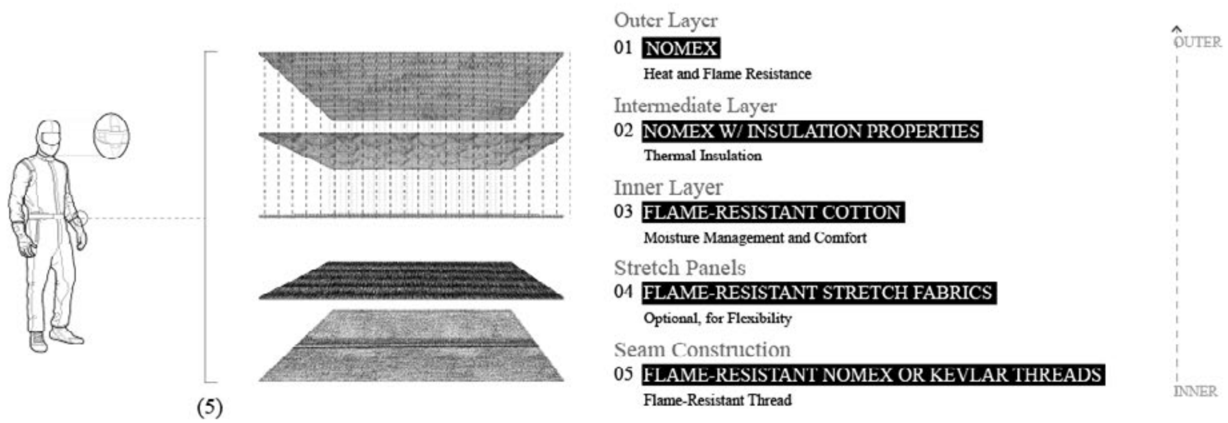
In artificial environments, **HIGH PERFORMANCE SUITS** such as ...

... are also hybridized systems that have **MULTIPLE HYBRID LAYERS** that work together as **ONE SYSTEM** to achieve the specific performance needed, such as protection and mobility in extreme environments or special functional needs within the space.

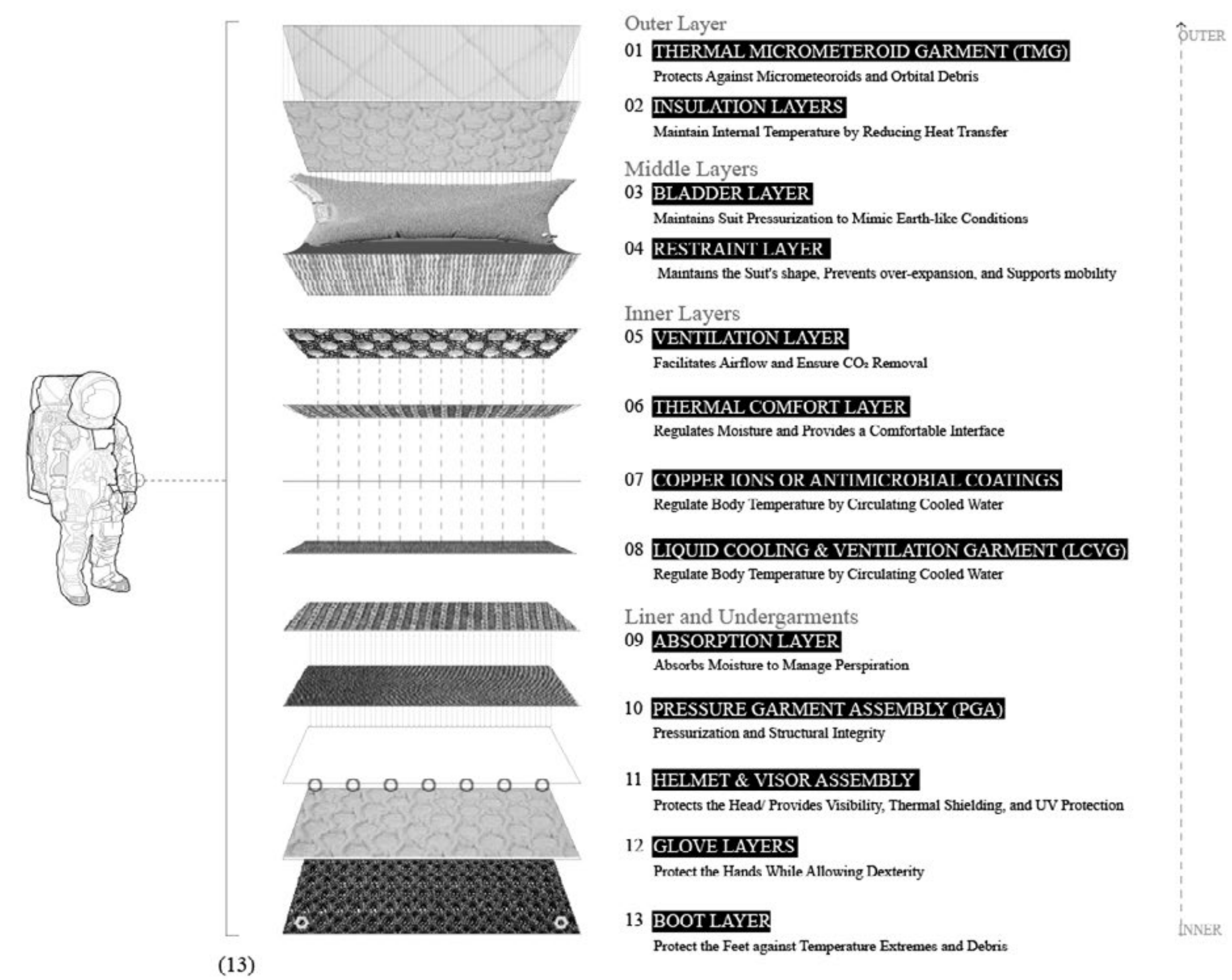
01 **Firefighter Cloth**



02 **F-1 Suit**



03 **EVA Suit**



+ *BUILDING TECTONICS*

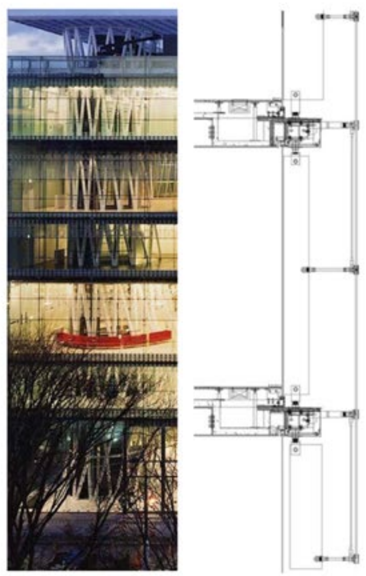


Figure 1. Sendai Mediatheque,
Toyo Ito

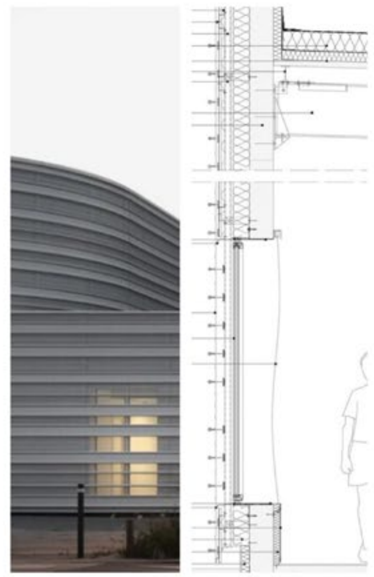


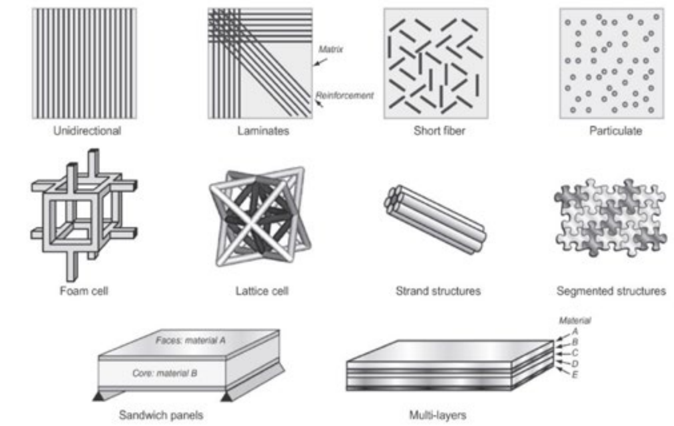
Figure 2. Sports Hall La Minai,
Bohuon Bertic Architectes

Figure 3. GIBOIRE Morbihan,
a/LTA Architects

In architecture, which is another artificial environment at a larger scale, having a hybridization system: we can see this in ***Mediateque***, from the glazed facade with attached hanging panels[1]; in ***Sports Hall La Minais*** the triple facade of metal framing, external insulation and aluminum sheet claddingg[2]; in ***GIBOIRE*** office building the double facade of a mass wall system and a glazed curtain wall[3].

In all cases, similarly, the hybridized system refers to the practice of combining different layers of **MATERIALS** and **TECHNOLOGIES** within a building's exterior components (such as walls, roofs, and windows) to achieve **OPTIMAL PERFORMANCE** in terms of thermal efficiency, energy conservation, structural integrity, aesthetics, etc.

+ *FUNCTIONAL GRADING - MICHAEL ASHBY*



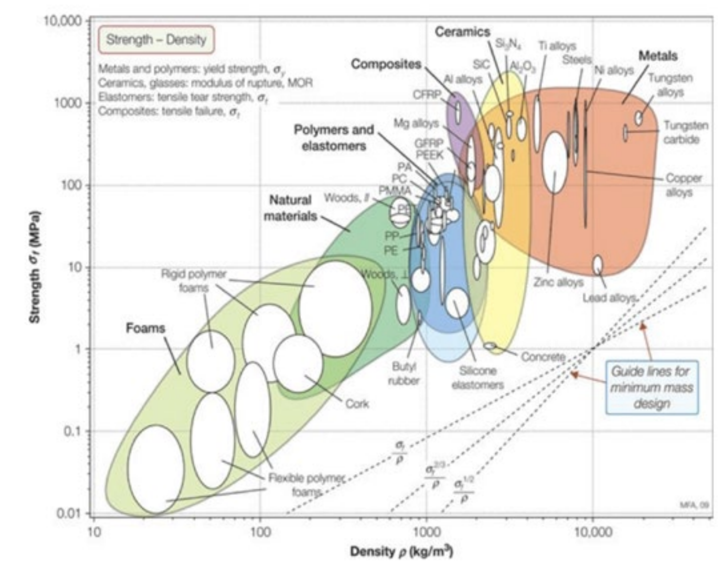


Figure 4. Ashby's material selection chart showing strength vs. density

MICHAEL ASHBY illustrates that material hybridization can take various forms—such as layering, mixing, segmenting, or structuring—allowing materials to surpass the limitations of uniform compositions.[4] By drawing out his material selection chart, he demonstrates how **FUNCTIONAL GRADING** can fill the **PERFORMANCE GAPS** of conventional materials by enabling the **CREATION OF TAILORED, HIGH-PERFORMANCE COMPOSITES**.

+ *EXAMPLES - MATERIAL GRADING*

Figure 5. Translucent Concrete

TRANSLUCENT CONCRETE incorporates light-transmitting aggregates within the mix allowing light to pass through while maintaining the structural strength of concrete.[5]

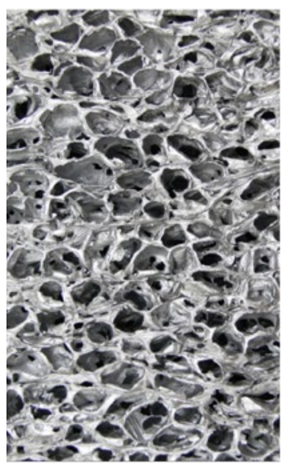


Figure 6. Metallic Foam

METALLIC FOAM has gas bubbles introduced into the molten steel, which hybridizes the material to become significantly lighter than solid steel yet still retains considerable strength .[6]

Figure 7. Fiber Reinforced Concrete

FIBER REINFORCED CONCRETE has the addition of fibers to add tensile strength to the concrete.[7]

+ *CASES STUDIES*

Figure 8. Cricket Shelter by Terreform ONE

CRICKET SHELTER blends biological systems with architectural fabrication achieving sustainable, food-producing shelter.[8]

Figure 9. Voromuro Pavilion by NADAAA

VOROMURO PAVILION is a hybridization of nature’s optimization patterns with technological fabrication allows for a highly flexible but still self-supporting structure.[9]

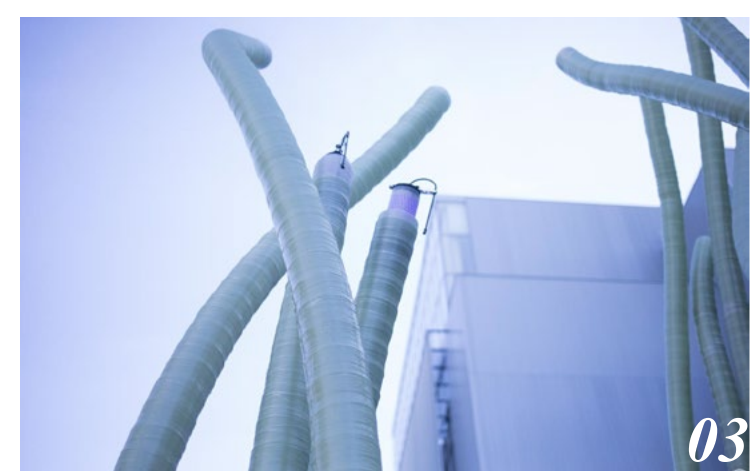
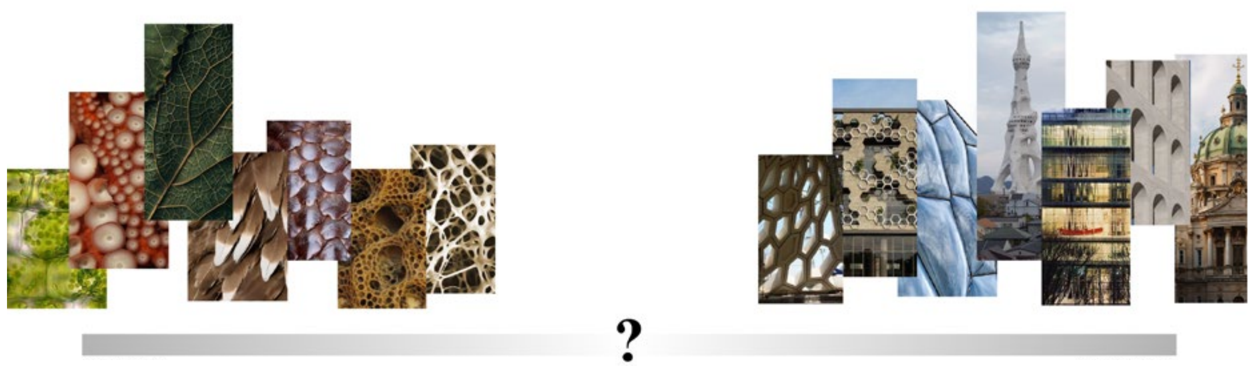


Figure 10. Fiberbots by MIT Media Lab

FIBERBOTS combines bio-inspired construction principles with autonomous robotic fabrication.[10] These robots mimics the way silk-worms and bees build habitats through additive layering.

+ *ENGINEERED vs NATURAL*



Artificially engineered building materials, such as glass and concrete, exhibit strength, rigidity, and durability. In stark contrast, their creators—human beings—are composed of relatively vulnerable soft tissues, susceptible to injury and deterioration. Compared to these engineered architectural materials, biological substances such as proteins and fatty tissues are often considered structurally inferior or "low-quality" in terms of mechanical robustness. This raises a critical question: how might such seemingly fragile organic materials be enhanced or pushed toward their maximum potential, stretching the perceived limits of their performance?

To enhance or restore physiological functions, some artificially engineered devices and materials that support or integrate with human tissue in the field of biomedical and tissue engineering. Medical implants including Pacemakers, Cochlear Implants, and Artificial Heart Valve work as the artificial core serving to re-engineer the internal material systems of the human body. These devices appear in X-rays as perfect forms made with human precision, at odds with their organic surroundings, appearing abrupt and even alien. However, paradoxically, they are often associated with the concept of "regeneration", symbolizing the restoration and enhancement of life rather than its destruction. Further, advancements in scaffold-based tissue engineering present remarkable opportunities.

+ *SCAFFOLDS for TISSUE ENGINEERINGS*

The method of scaffolds features a hybridization between a precisely designed structure composed of synthetic bio materials. The cultivated cells have been facilitated, guided, and integrated with native tissue within the provided three-dimensional spaces. Thus, these engineered scaffolds contribute to improved mechanical stability, bio activity, and tissue compatibility.[11] A compelling example of scaffold-based tissue engineering is the Vacanti mouse experiment. The study titled "Transplantation of chondrocytes utilizing a polymer-cell construct to produce tissue-engineered cartilage in the shape of a human ear" by Y. Cao et al. implement chondrocytes onto a biodegradable polymer scaffold shaped like a human cuticle and then implanted into mice.[12] This bio-construction, over time, grows seamlessly on mice and develops into the cartilage structures resembling the intricate geometry of a human ear. This type of artificial organ implantation functions less as a stand alone high-performance device and more as the creation of an entirely new powerful hybridized system—one that integrates synthetic structures with living biological components.

Figure 11. Vacanti Mouse

\+ **RESEARCH METHODOLOGY**

02

+ *PRACTITIONERS*

Figure 12. Vespers II Death Mask Series by Neri Oxman

Practitioners such as Neri Oxman, Self-Assembly Lab, and MIT Media Lab lead their research on biological processes represented within the means of digital fabrication and material sciences. Rather than proposing immediate real-world interventions, our focus is on pushing conceptual boundaries and imagining new possibilities through the lens of a hybridized system. Neri Oxman's Vespers Death Mask Series exemplifies hybridization by merging biological processes, digital fabrication, and material science.[13] Blending ancient rituals with futuristic, bio-engineered materials, the masks utilize 3D printing and computational design to create intricate, multi-material structures. The research methodology being practiced with provides ***MORPHOGENESIS*** a feasible growth environment and pushes the project to evolve further and further.

+ *SCI-FI NARRATION*

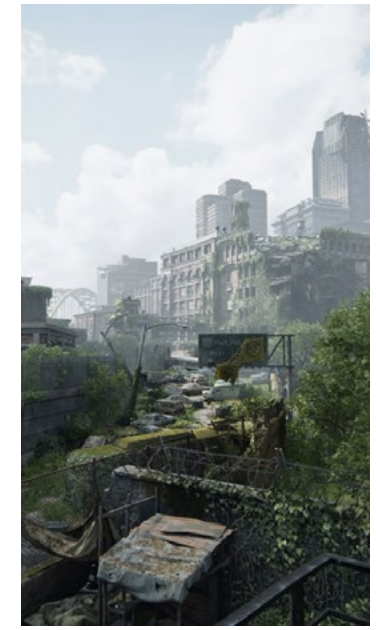


Figure 13. The Last of Us

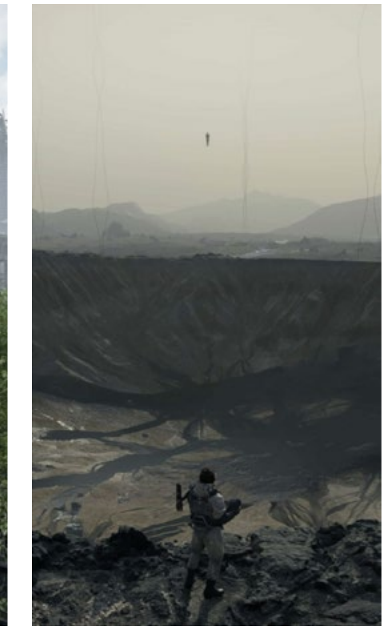


Figure 14. The Death Stranding

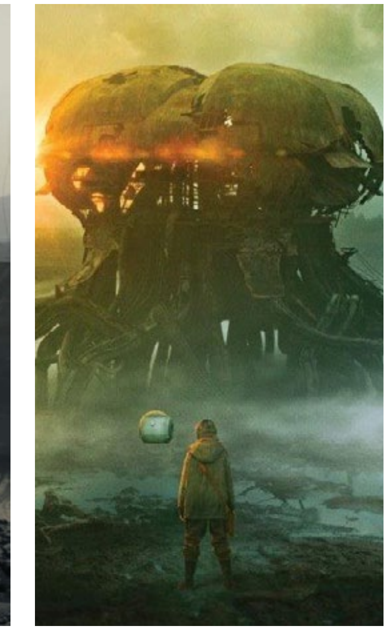


Figure 15. Vesper

To create a research environment that would help continue the narrative of ***MORPHOGENESIS***, a science-fiction framework can significantly support and expand the scope. It provides ***MORPHOGENESIS*** with an imaginative yet structured space to envision future scenarios, test radical concepts, and challenge traditional boundaries between biology, technology, and architecture. Virtual realities, games and movies' worldviews such as ***The Last of Us***[14], ***Death Stranding***[15], and ***Vesper***[16] are inspiring and provoke deep speculation on how organisms, environments, and technology might co-evolve in response to ecological collapse or biological transformations. These futuristic references show how humans and buildings have adapted to such changes, imaging the worst possible scenario in which human instincts, capabilities and key mechanisms have allowed for survival despite such circumstances.

+ **WORLDVIEW**

03

+ *NARRATIVE*

An extinction event is always accompanied by a sharp decrease of about 80% in the diversity and abundance of multicellular organisms and a welcome to the next era. Earth has recorded five major mass extinction events, often called the “Big Five.” However, it is difficult to regard these events as a true cycle due to their unpredictable timing and the complex causes behind each one.

The true Sixth Mass Extinction began in the year 2125, when Earth, once again, was entirely veiled in green. This uncontrolled growth of vegetation was first recorded at the Great Salt Lake. What was once a barren, salinized land—exposed to the harshness of the elements—had become obscured by an unrelenting veil of green. These plants were not overtly hostile to the researchers who ventured into the area; instead, they simply grew. And grew. Their relentless expansion seemed beyond control, as if nature itself had decided to reclaim what had been lost.
After centuries of deforestation, urbanization, pollution, climate change, and the overexploitation of resources, the vegetation had become impervious to both physical and chemical assaults. Scientists now believed that this behavior was not merely an adaptation, but a form of resistance. It was as if the plants were fighting to recover the territory they had lost—an act of reclamation that had turned into a force of unstoppable growth.

The Sixth Mass Extinction was not a catastrophe of fire, ice, or asteroid strikes. It was the earth's final, overwhelming response to human encroachment—a quiet, relentless end. Nature had begun its counteroffensive. To carve out spaces that could sustain human life in this world now ruled by relentless vegetation, architecture would have to evolve. It could no longer be built in the same way. Instead, a new, more organic approach would be required—one that harmonizes with the unstoppable growth surrounding it, blending seamlessly into the very fabric of nature.

To design a solution for habitable spaces capable of coexistence with their environments, architects embarked on the Morphogenesis project—a proposal that simulates nature through a hybridized system functioning as a living entity, responsive and adaptive to accelerated climate change conditions and the onset of what scientists have termed the Sixth Mass Extinction. After centuries of deforestation, urbanization, pollution, and resource exploitation, vegetation evolved beyond physical and chemical suppression, demonstrating behaviors researchers interpret not merely as adaptation but as active resistance. This relentless expansion of greenery overwhelmed existing infrastructures and rapidly depleted cultivable land, rendering traditional modes of human survival obsolete. Recognizing the imperative for architecture itself to evolve in response to nature's reclamation, scientists and architects developed Morphogenesis as an experimental approach. The initiative, with the heart of Manhattan selected as its initial test site, marked a pivotal shift in architectural design, envisioning habitable structures that could not only coexist with nature but actively mutate and thrive alongside it, becoming integral components of a larger ecosystem.

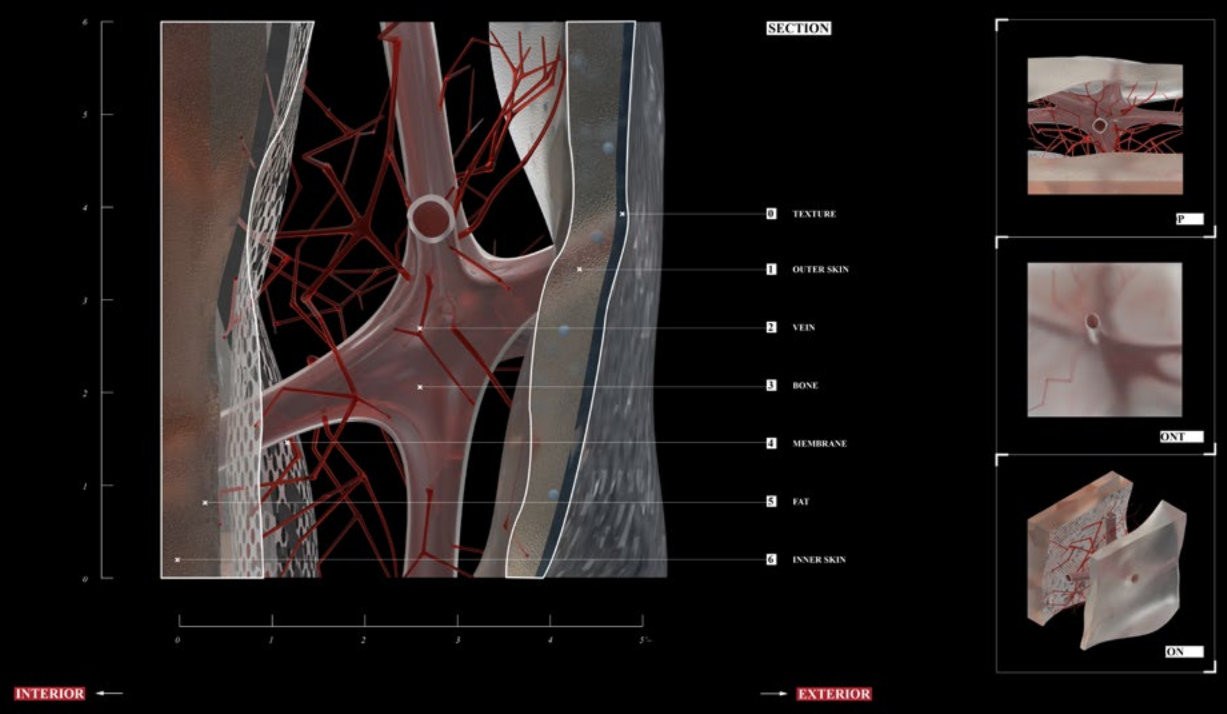
+

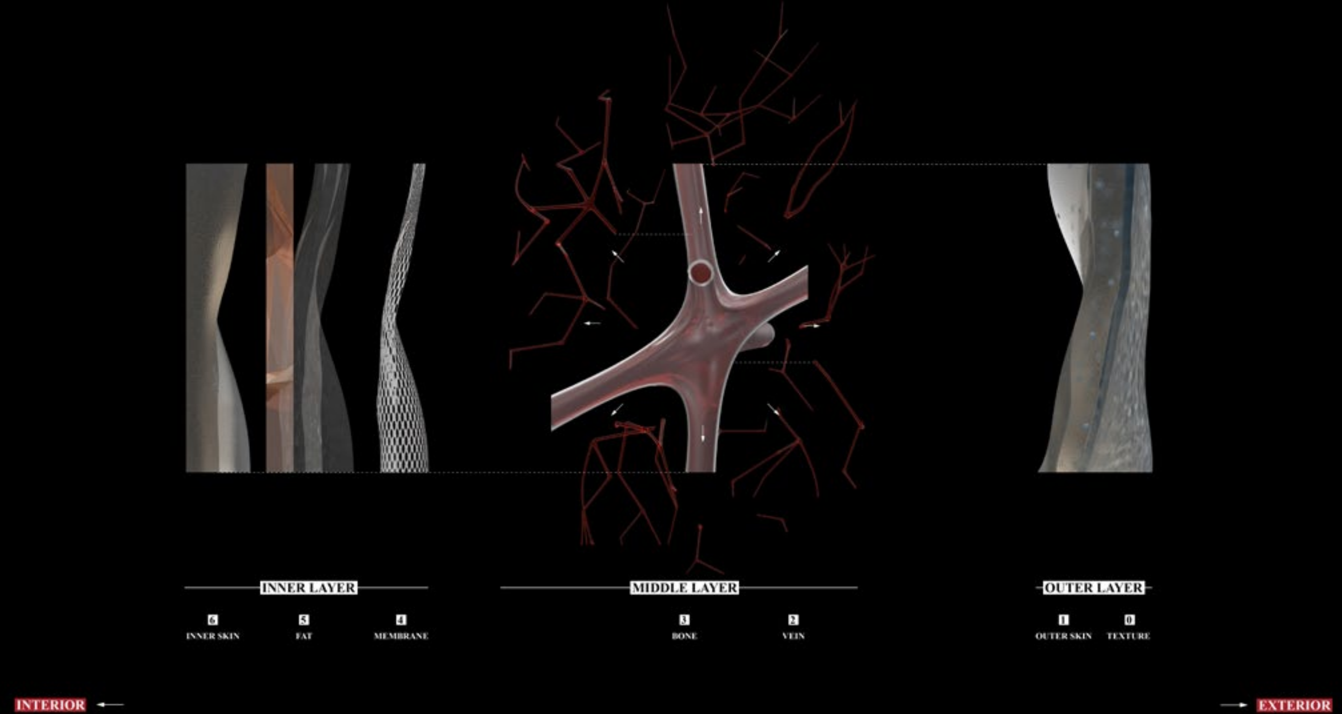
REPRESENTATION & FABRICATION

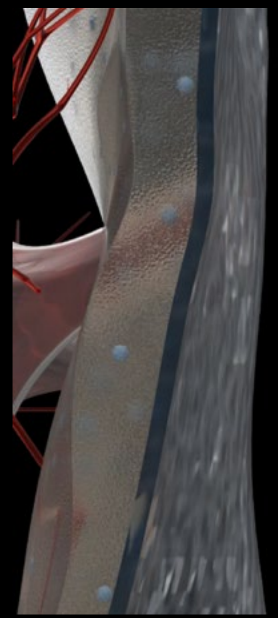
04

+ FIRST PROTOTYPE

MORPHOGENESIS is envisioned as a structure composed of bone, vein, membrane, fat, and skin—each element contributing to a multi-functional architectural façade. Analogous to the growth of human and animal bodies, the system originates from a central core—its "bone"—and develops outward.



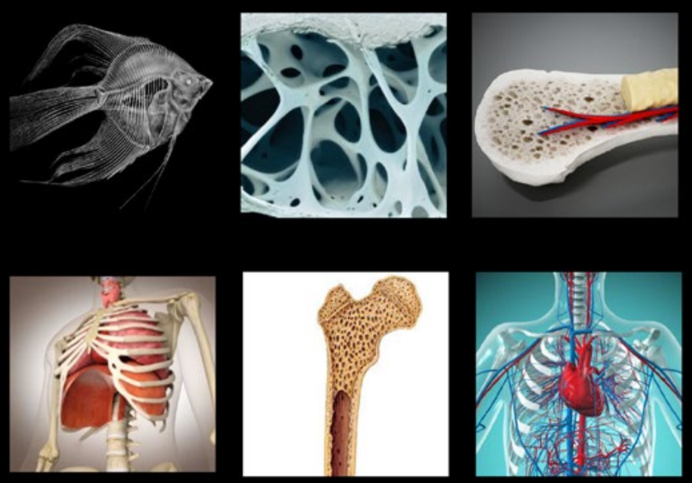




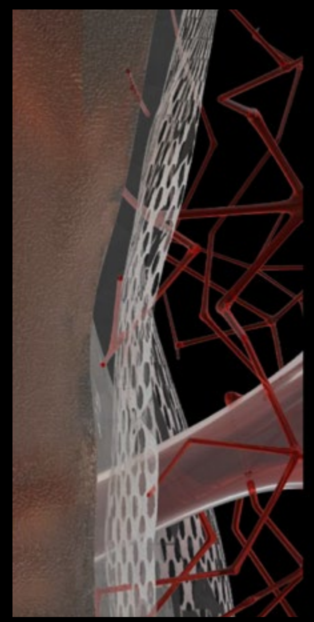
1. THE OUTER LAYER

 # Protection
 # UV Protection
 # Aesthetics
 # Insulation

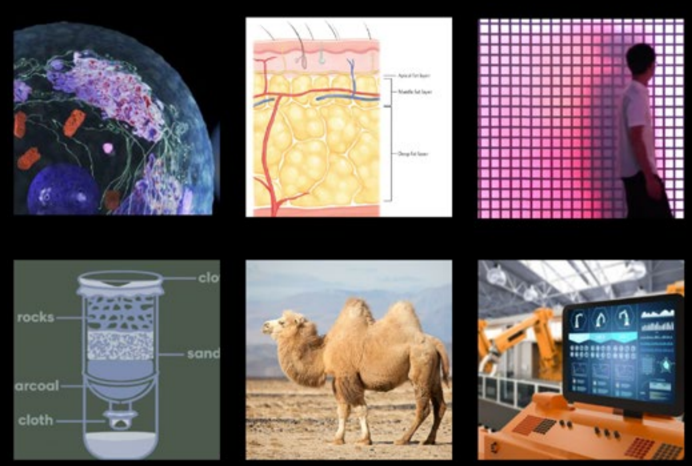
1. THE MIDDLE LAYER



 # Structural Stability
 # Internal Protection
 # Hollow Structure
 # Circulatory System

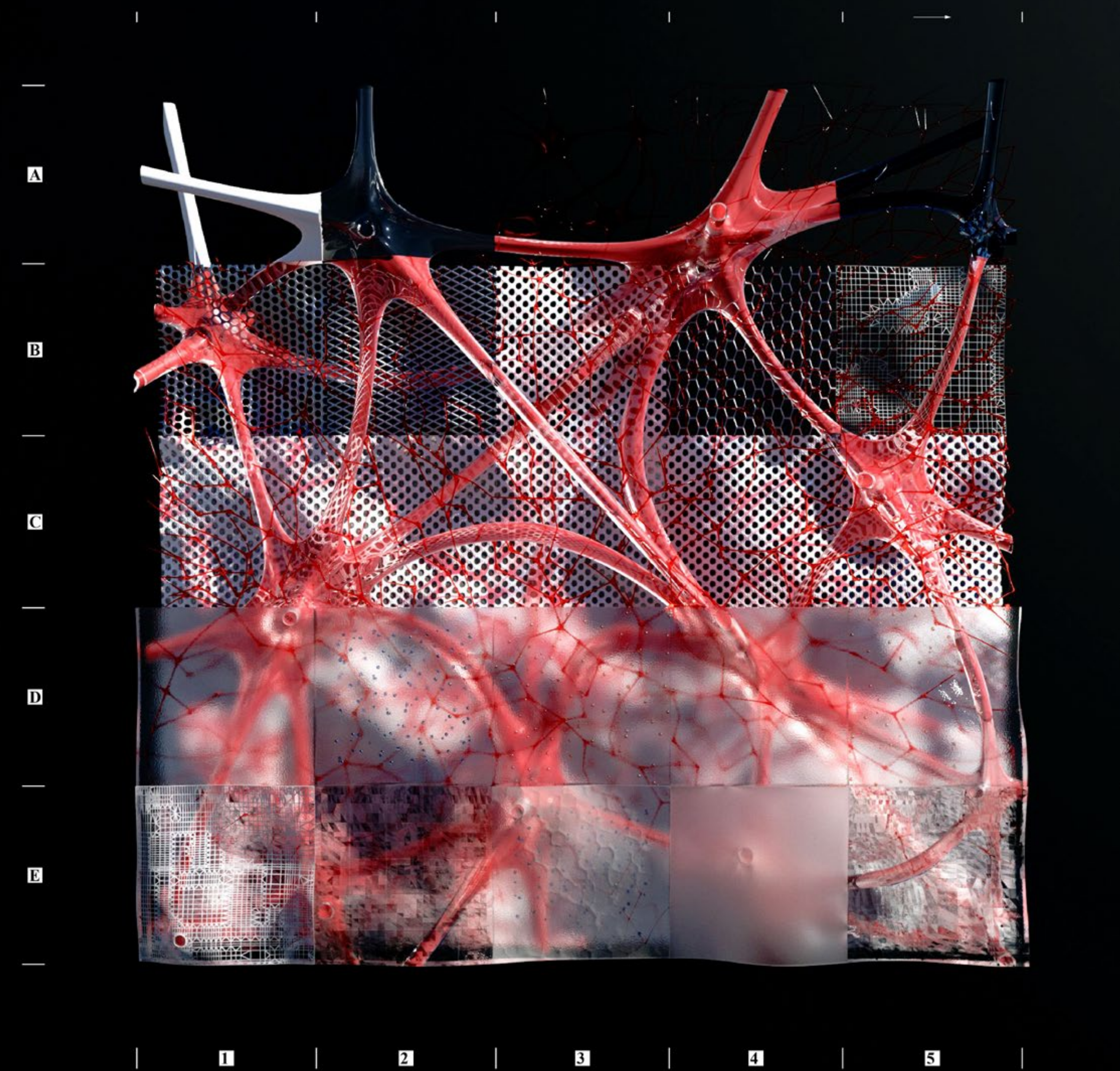


3. THE INNER LAYER



 # Energy Storage
 # Insulation
 # Barrier & Filtration
 # Interface

+ 3x3 MODEL IMAGINATION

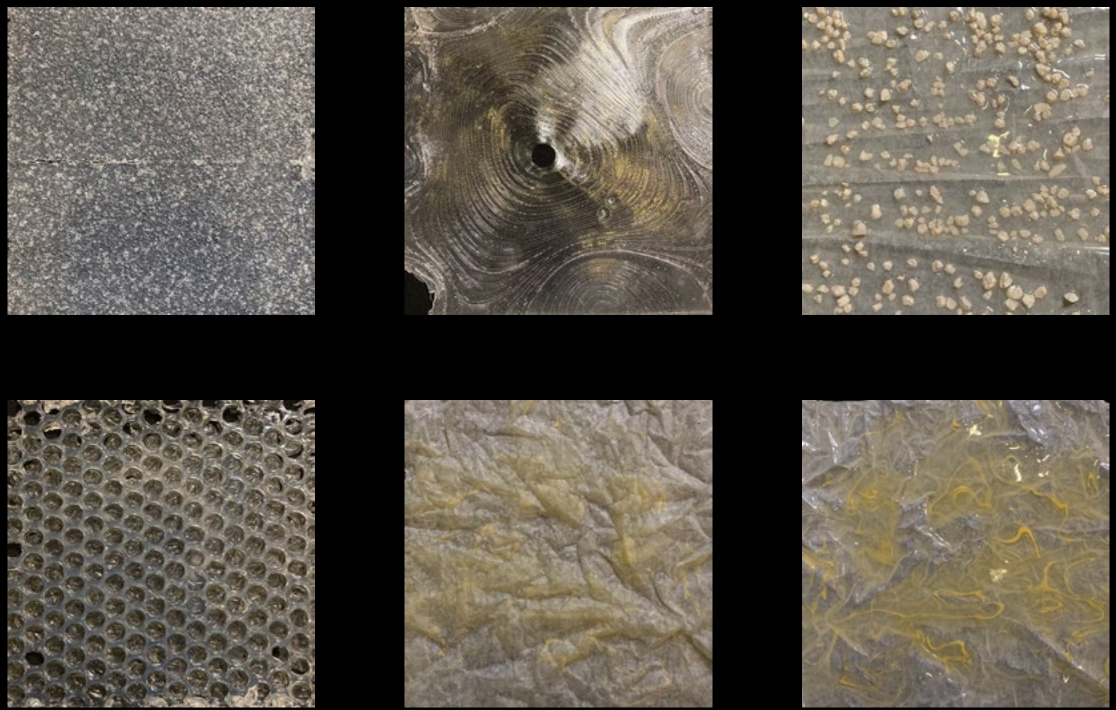


The ***MORPHOGENESIS*** system evolves through phases that parallel the conceptual development of the research. Beginning with a skeletal structure, additional layers—veins, membranes, and fat—are progressively integrated to support performance, adaptability, and environmental response. The result is a speculative yet rigorously developed proposal for a living, hybridized architectural system—a genesis.

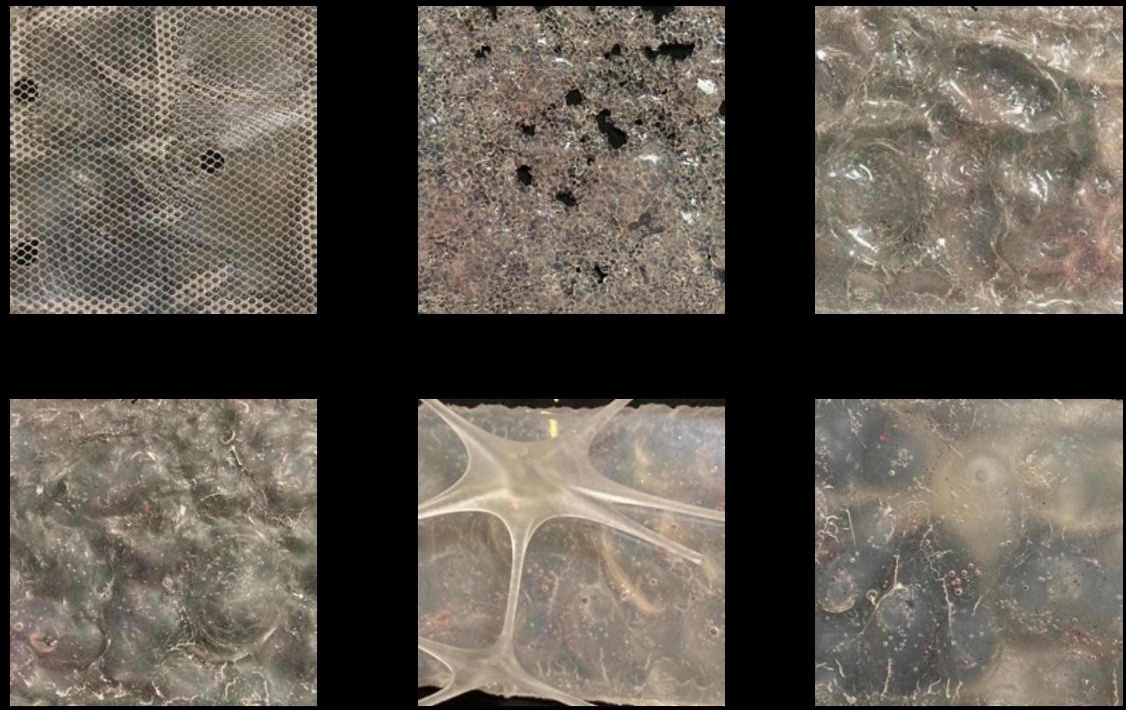
+ REPRESENTATION SAMPLES

SOFT SKIN SAMPLE

SKIN + TEXTURE / STRUCTURE SAMPLE



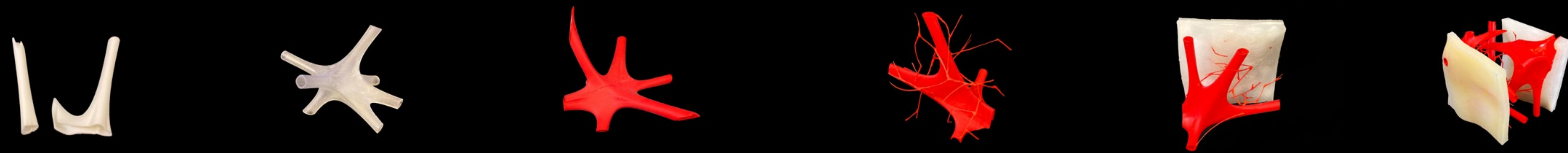
TEXTURE SAMPLE



TEXTURE SAMPLE

+ REPRESENTATION SAMPLES

PHYSICAL SAMPLES



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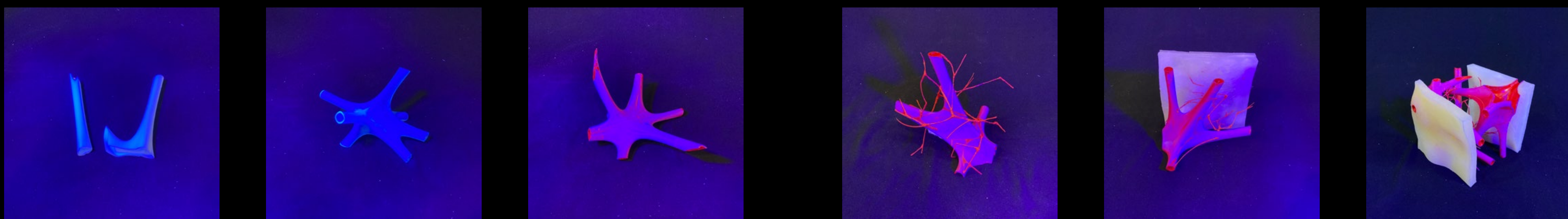
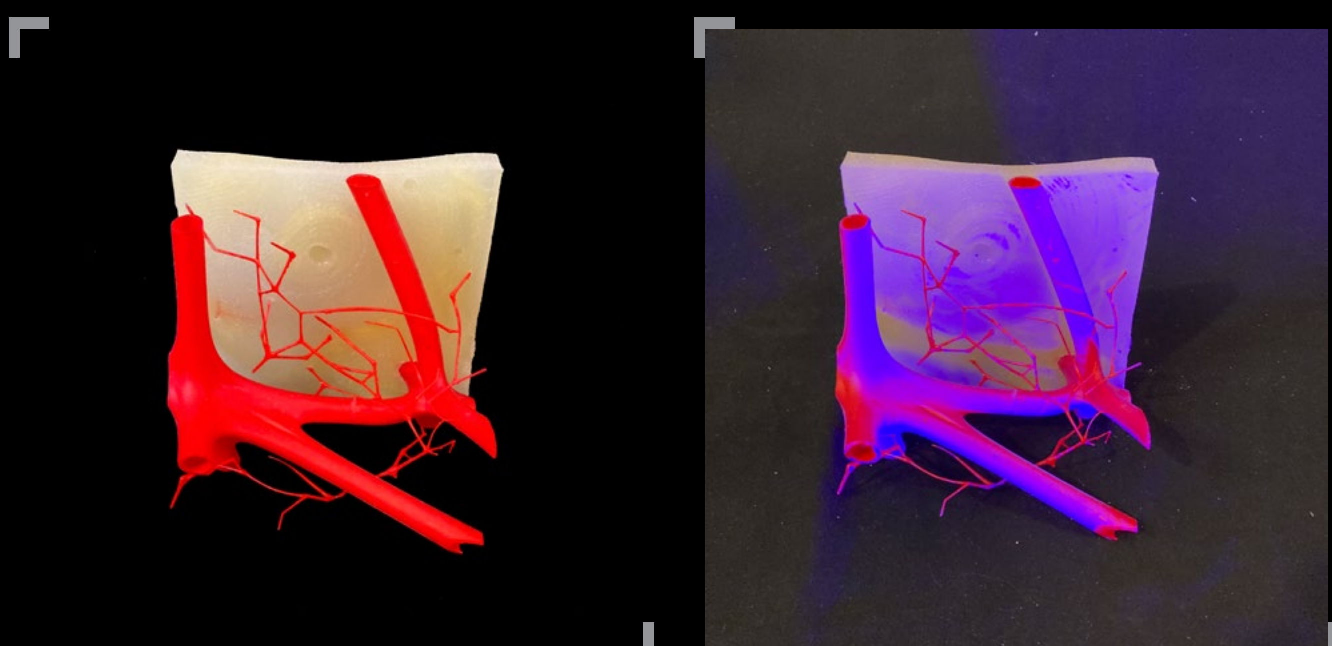
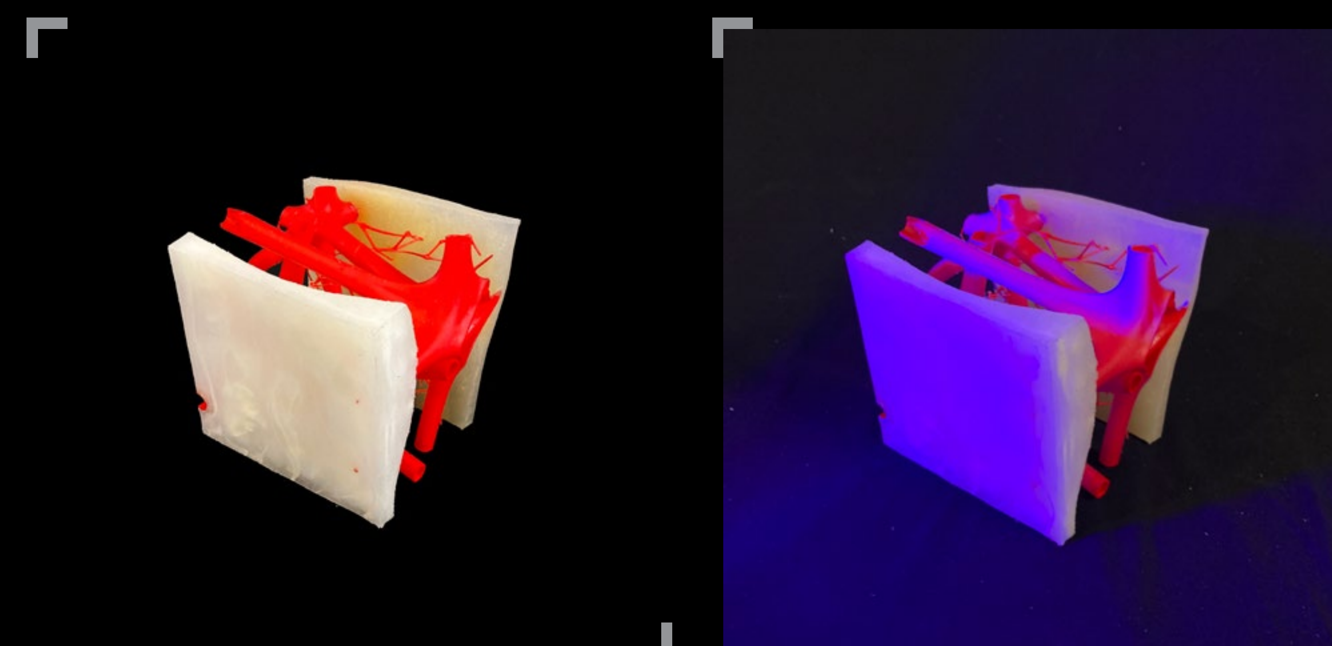




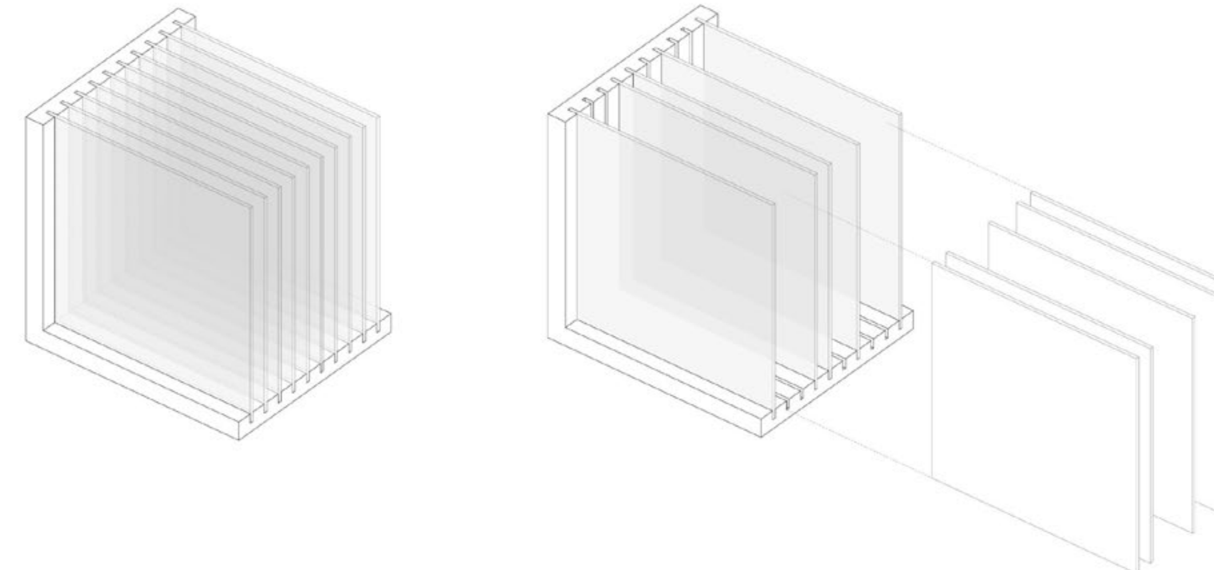


+ REPRESENTATION SAMPLES

MATERIAL LIBRARY

To further support the experimental process, a Material Library was developed as a flexible system for simulating and testing different material hybridizations.

The library consists of 10 distinct layers, each representing a unique material mutation with specific textural, structural, and functional characteristics. These layers are modular—they can be slid in or out individually, allowing for the customization, stacking, or isolation of different combinations based on desired environmental performance or adaptive behavior.



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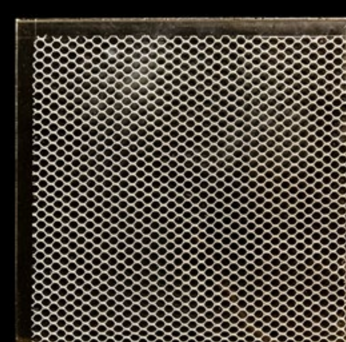

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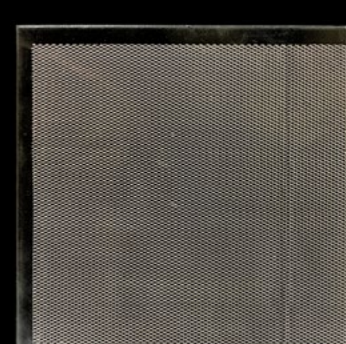

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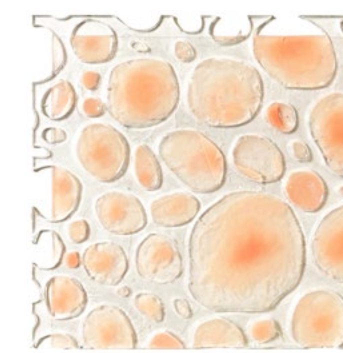

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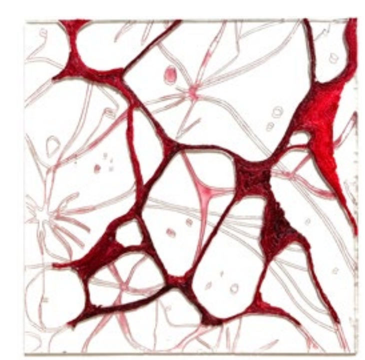

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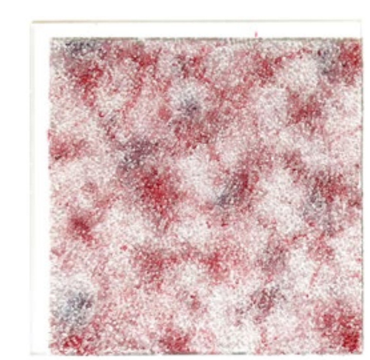


10

+ REPRESENTATION SAMPLES

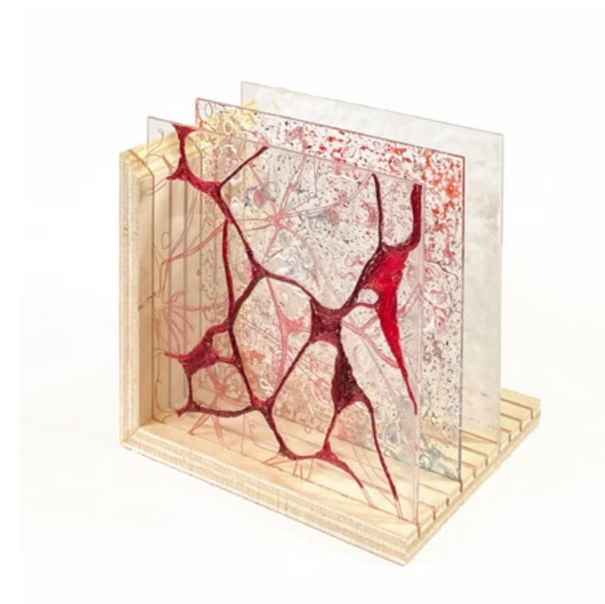
COMBINATION EXAMPLE

This interactive system enables the exploration of a wide range of hybridized material conditions, from dense, protective exteriors to porous, breathable membranes, reflecting the evolutionary logic found in natural organisms. Through rearrangement and recombination, new composite behaviors emerge, providing insight into how a ***MORPHOGENESIS*** system might dynamically adapt to evolving environmental challenges.

The Material Library thus serves both as an archive of mutational studies and as a design tool for generating future responsive architectural skins.

01 + 02 + 10

08 + 09 + 03



02 + 07 + 05

+ REPRESENTATION SAMPLES

01
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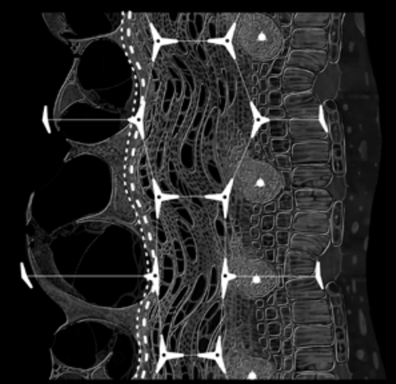
06

+ REPRESENTATION SAMPLES

MRI (Magnetic Resonance Imaging)

Its performance is monitored in real time using MRI technology, which produces detailed sectional images of the internal composition and dynamic behaviors of the structure. This technique allows the researchers to track structural transformations and environmental responses across different zones of the system. In the following case studies, several representative examples are presented to illustrate the mutational behaviors observed within the artificial structures.



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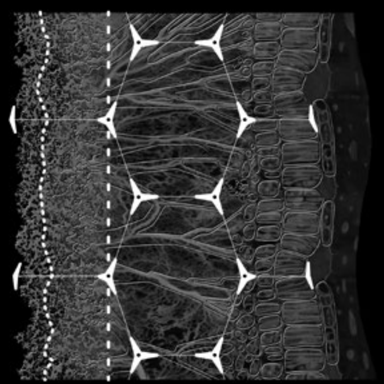

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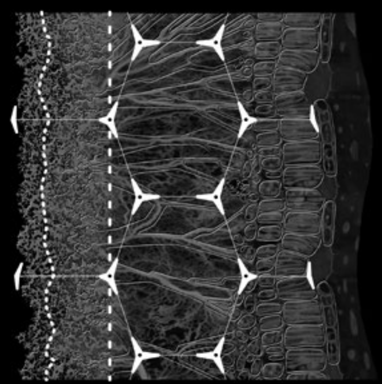

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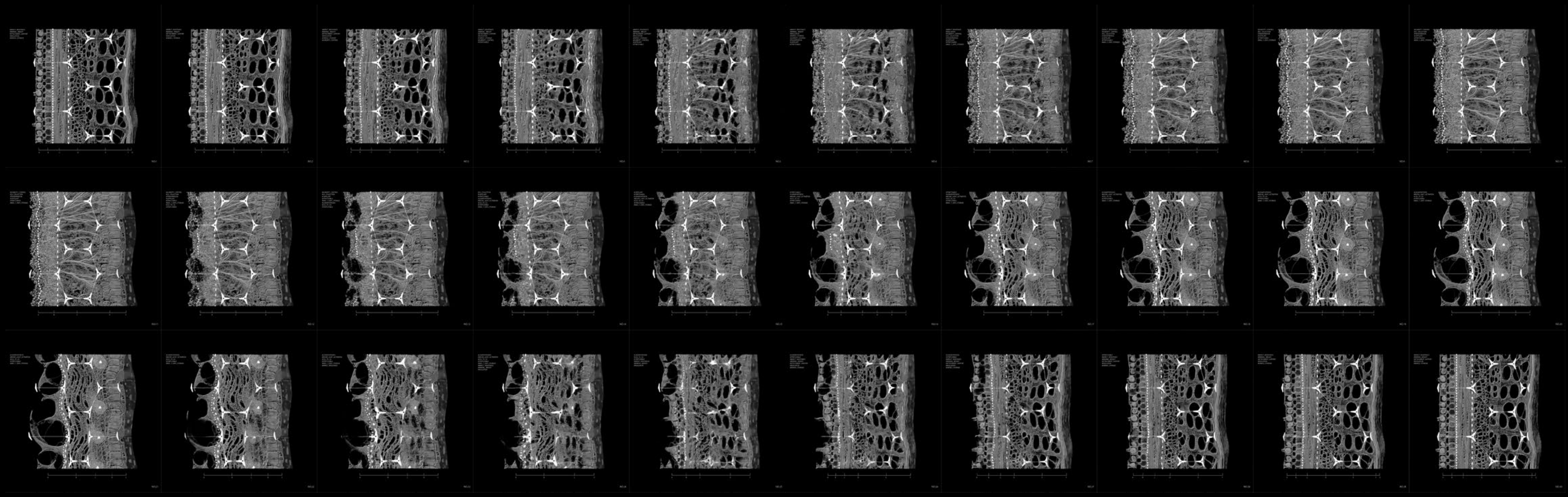
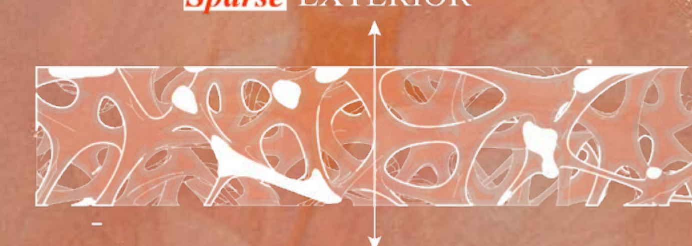


BONE ELEVATION

+

WAVESKIN

Sparse EXTERIOR

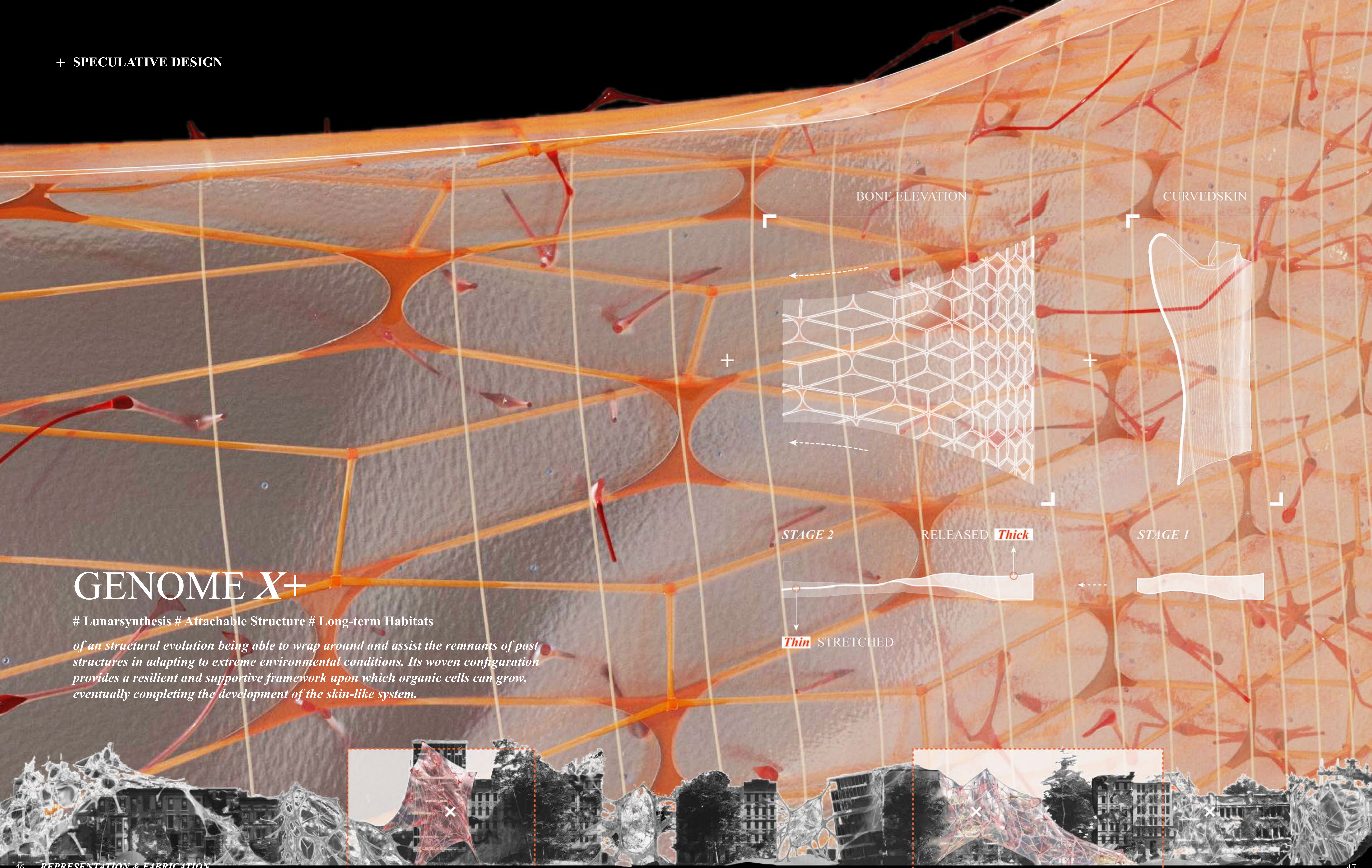


INTERIOR *Dense*

GENOME *Y+*

 # Lunarsynthesis # Attachable Structure #Long-term Habitats

of future inhabitable space involves structures that are attached to existing buildings. Its extensions rely on rigid structural elements for foundational support, and its graded structure enables more precise control over the growth direction of the soft architectural material-organism.



GENOME *X*+

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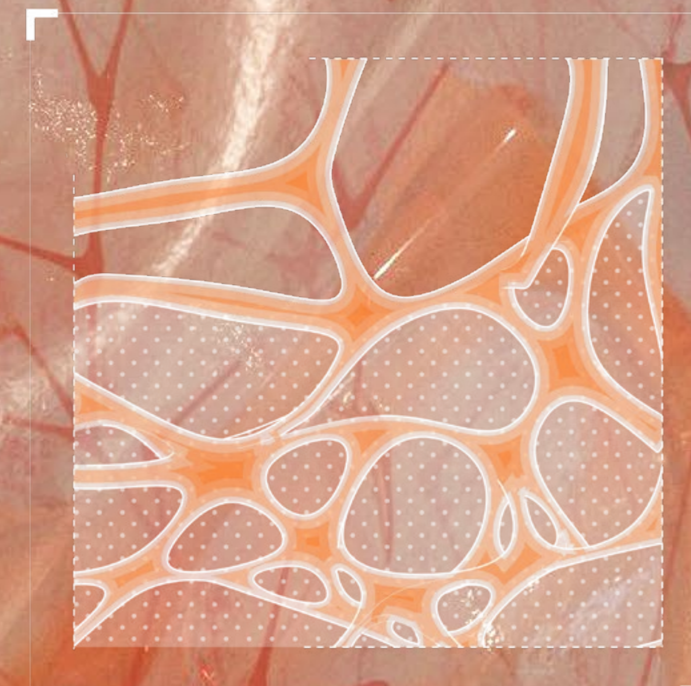
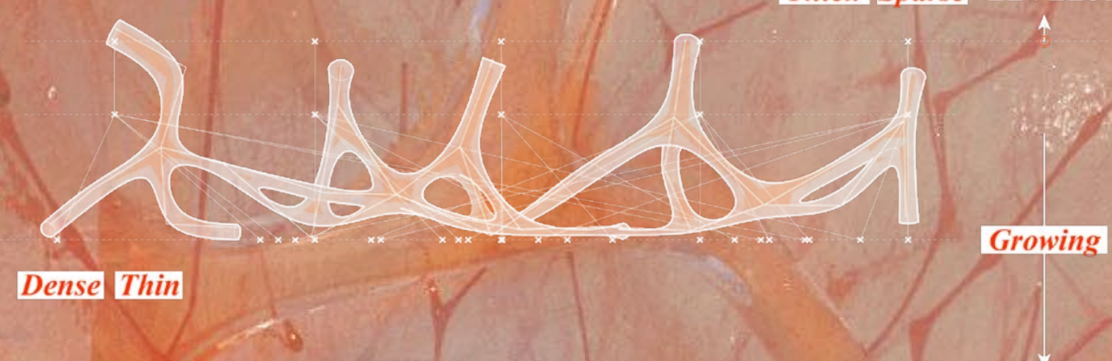
of an structural evolution being able to wrap around and assist the remnants of past structures in adapting to extreme environmental conditions. Its woven configuration provides a resilient and supportive framework upon which organic cells can grow, eventually completing the development of the skin-like system.

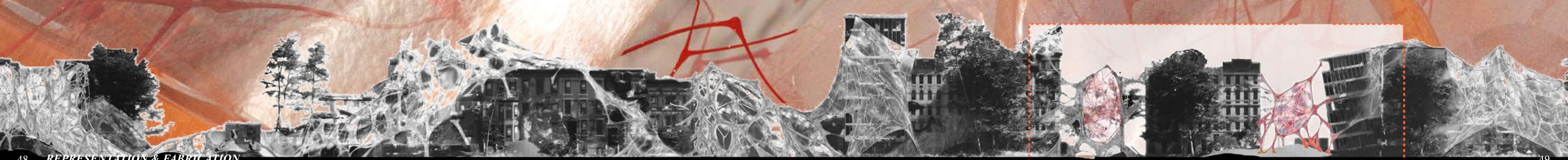
GENOME *S*+

 # Resource Collections # Protection # Short-term Living-Envir

features an exoskeletal structure echoing the graded structural logic of previous types. Its skeleton is several times more massive, embedded with spikes to enhance its defensive capabilities and primarily focus on harvesting natural resources to fulfill the basic survival needs.

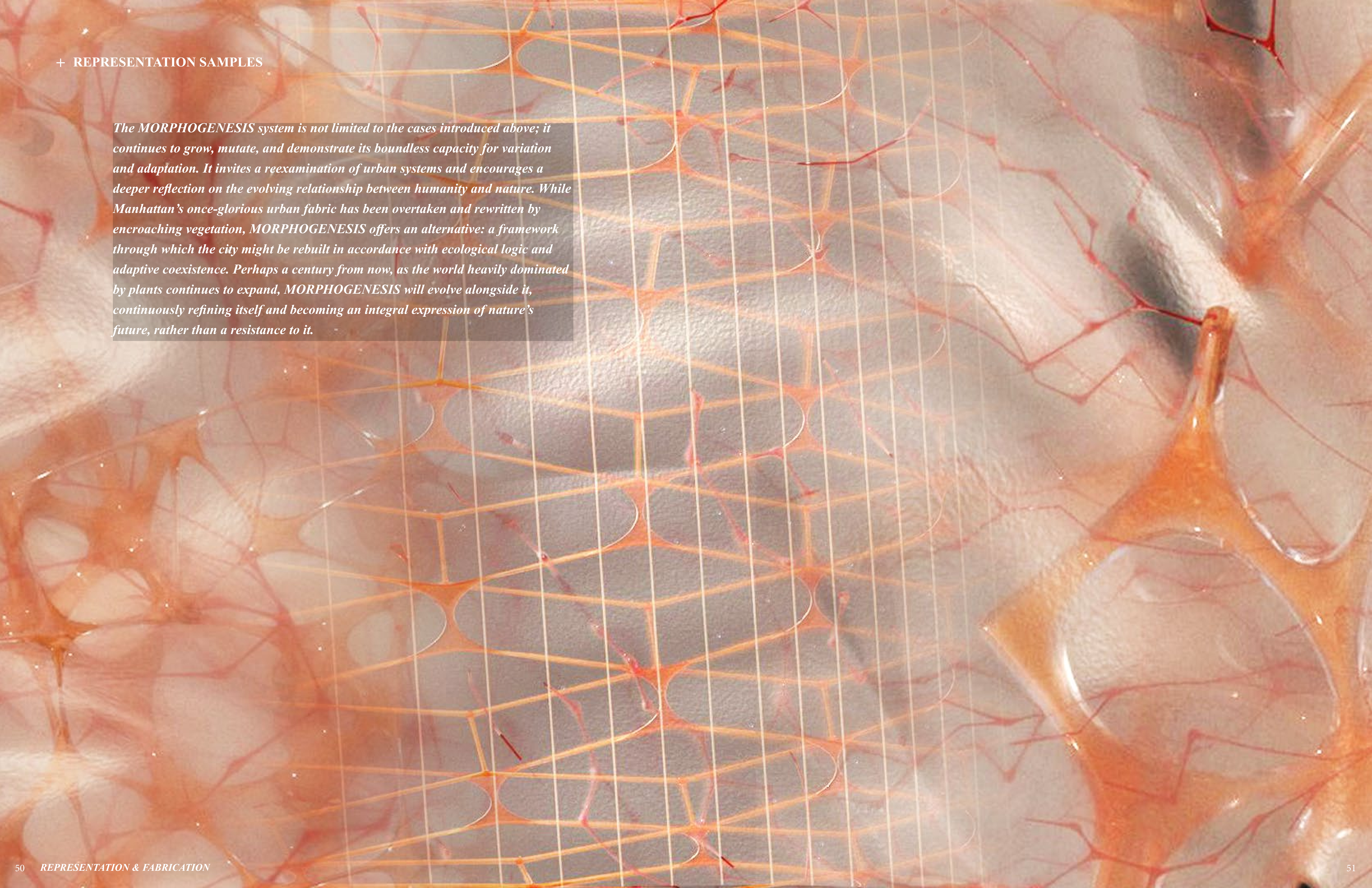






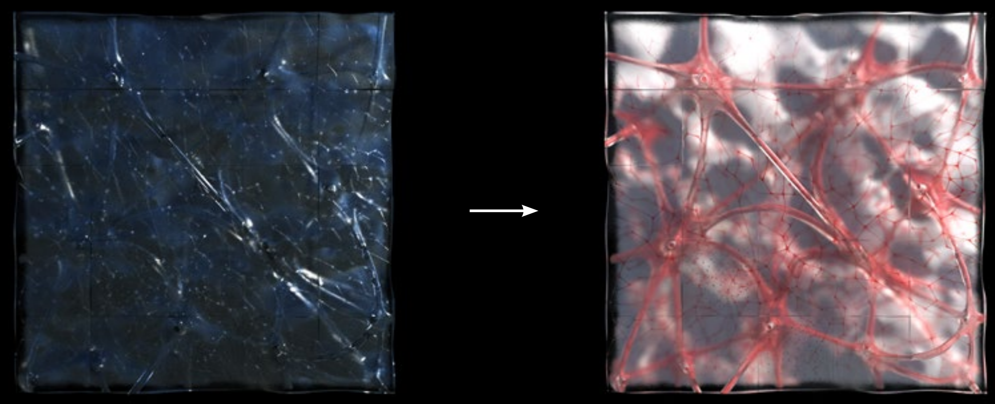
+ REPRESENTATION SAMPLES

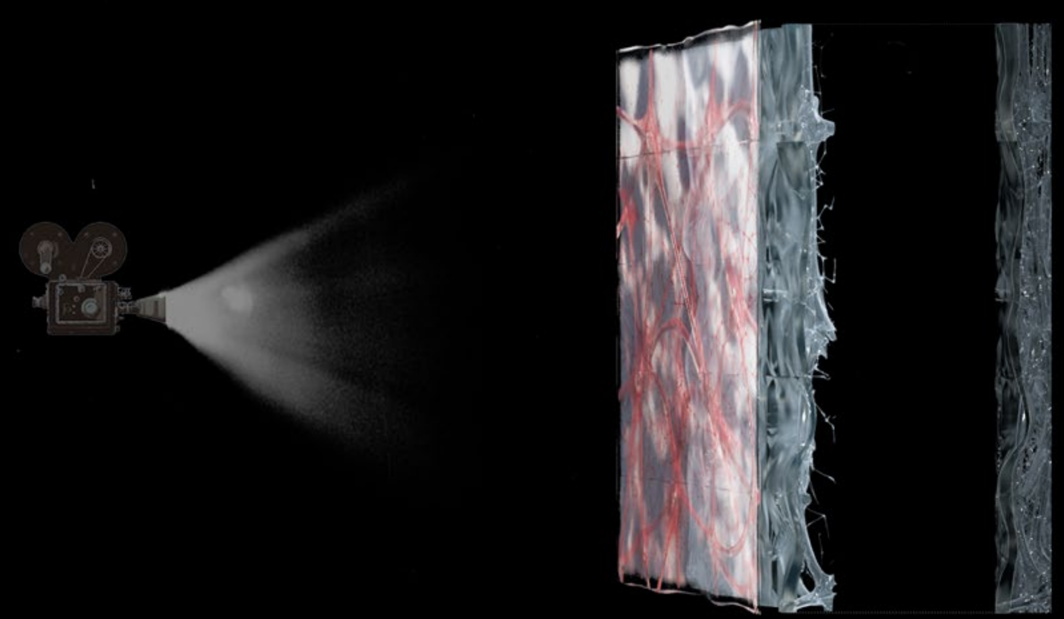
The MORPHOGENESIS system is not limited to the cases introduced above; it continues to grow, mutate, and demonstrate its boundless capacity for variation and adaptation. It invites a reexamination of urban systems and encourages a deeper reflection on the evolving relationship between humanity and nature. While Manhattan's once-glorious urban fabric has been overtaken and rewritten by encroaching vegetation, MORPHOGENESIS offers an alternative: a framework through which the city might be rebuilt in accordance with ecological logic and adaptive coexistence. Perhaps a century from now, as the world heavily dominated by plants continues to expand, MORPHOGENESIS will evolve alongside it, continuously refining itself and becoming an integral expression of nature's future, rather than a resistance to it.



+ PROJECTION

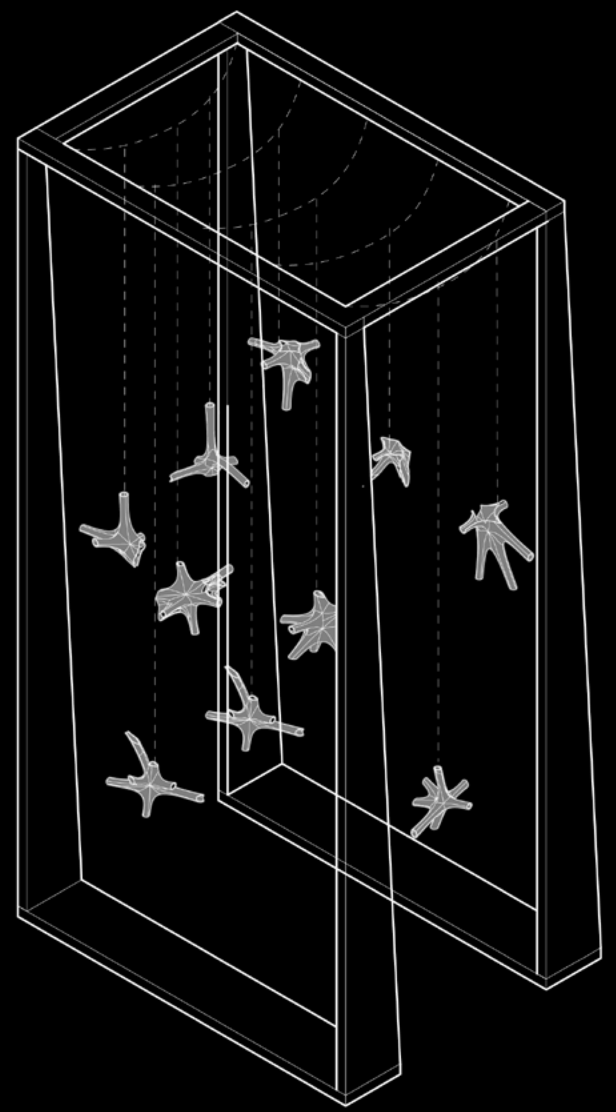
To enhance audience understanding and immersion within the envisioned world, the researchers have constructed an on-site projection installation. This immersive experience enables viewers to engage more rapidly and effectively with the project's conceptual framework, while also observing the mutational process of Morphogenesis in real time. Through this installation, the audience is not merely positioned as passive observers or survivors within a speculative future, but as active participants who momentarily share the perspective of the scientist-architects behind the system's creation.



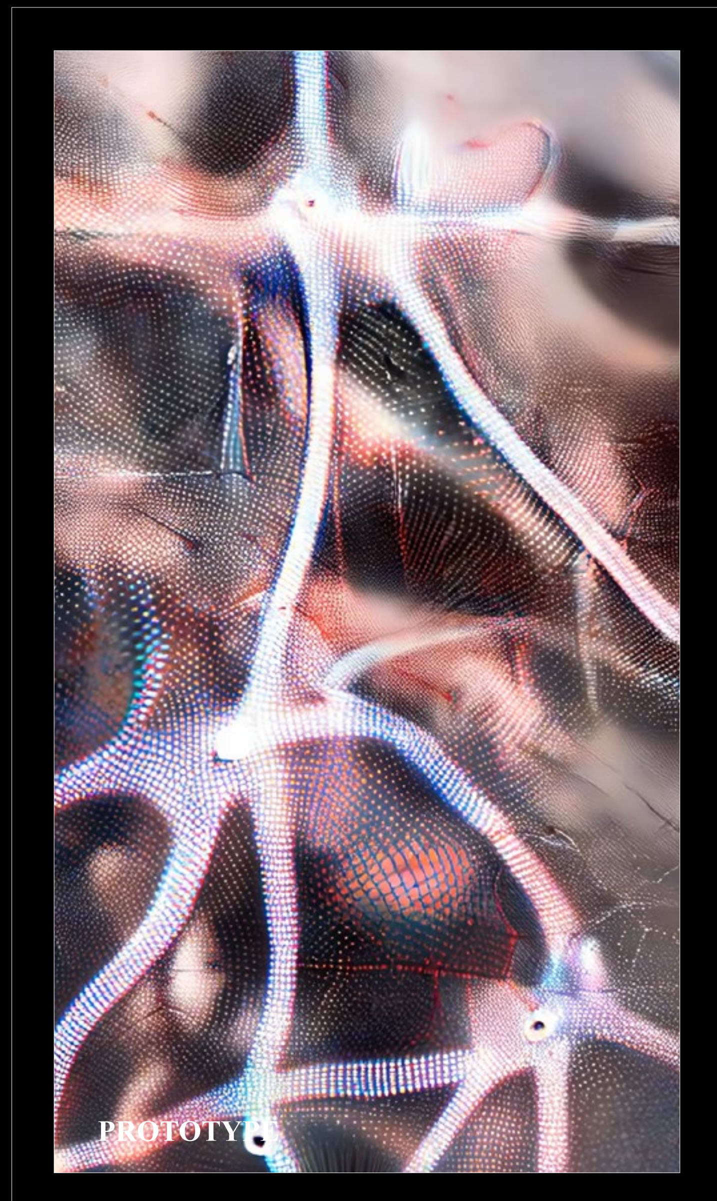


+ REPRESENTATION SAMPLES

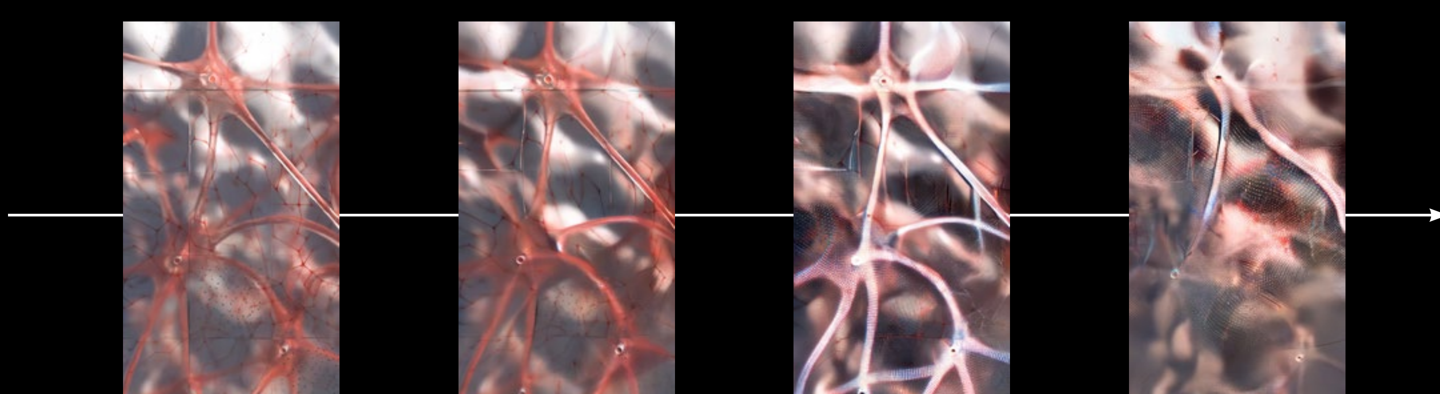
The projection is divided into three theoretical phases, representing the outer, middle and innermost layers of the prototype of ***MORPHOGENESIS***. As the mutations occur and cause the facade system to shift and change its organic structure over time, the outer and inner layers reflect these changes occurring and processing over time. Stimulated by a series of environmental factors, the projections aim to represent the dynamic adaptation processes of the ***MORPHOGENESIS*** system, illustrating how its layered structure evolves in response to shifting external conditions, resource availability, and survival needs.



+ PROJECTION ANIMATION



ITERATION 01



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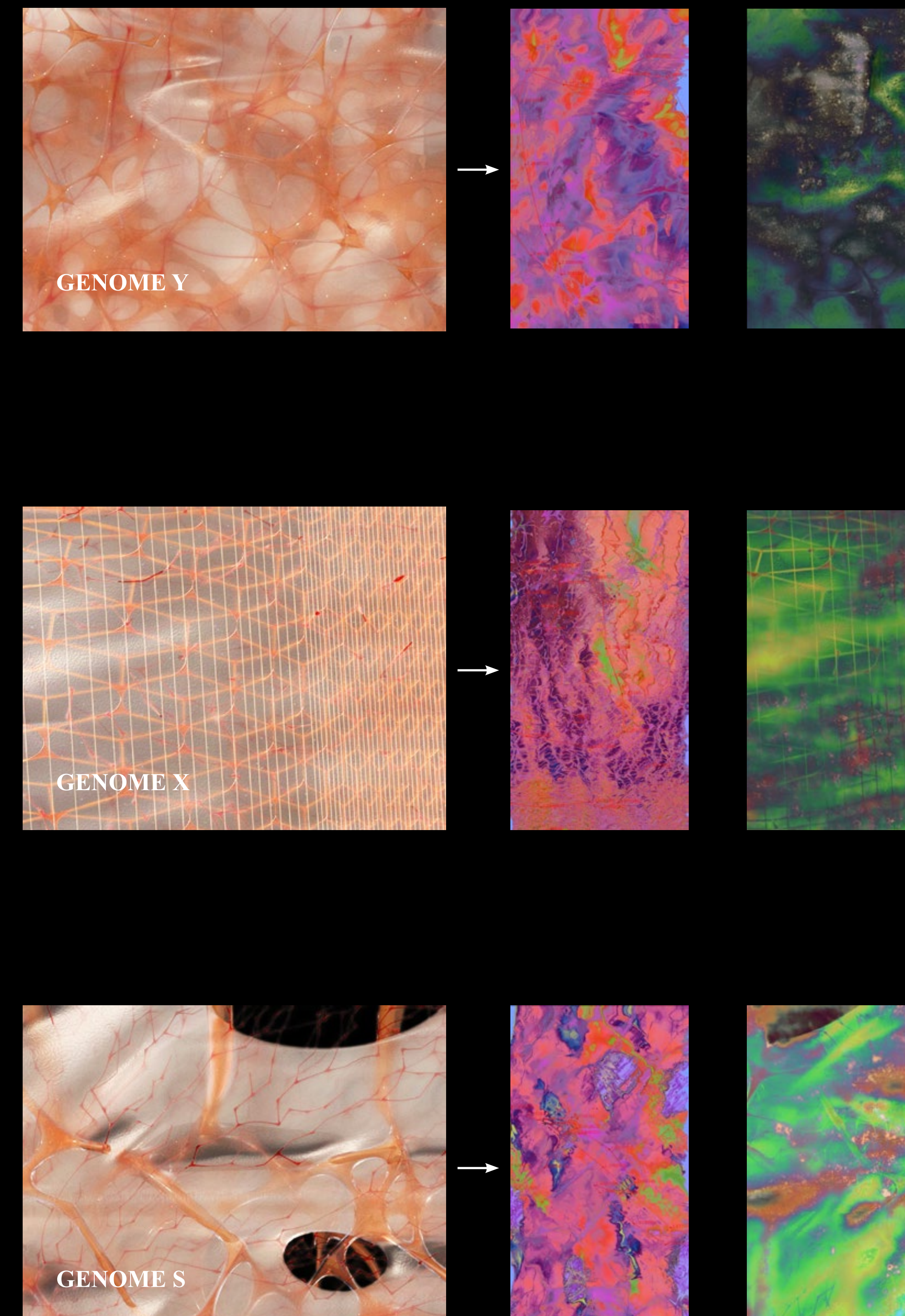
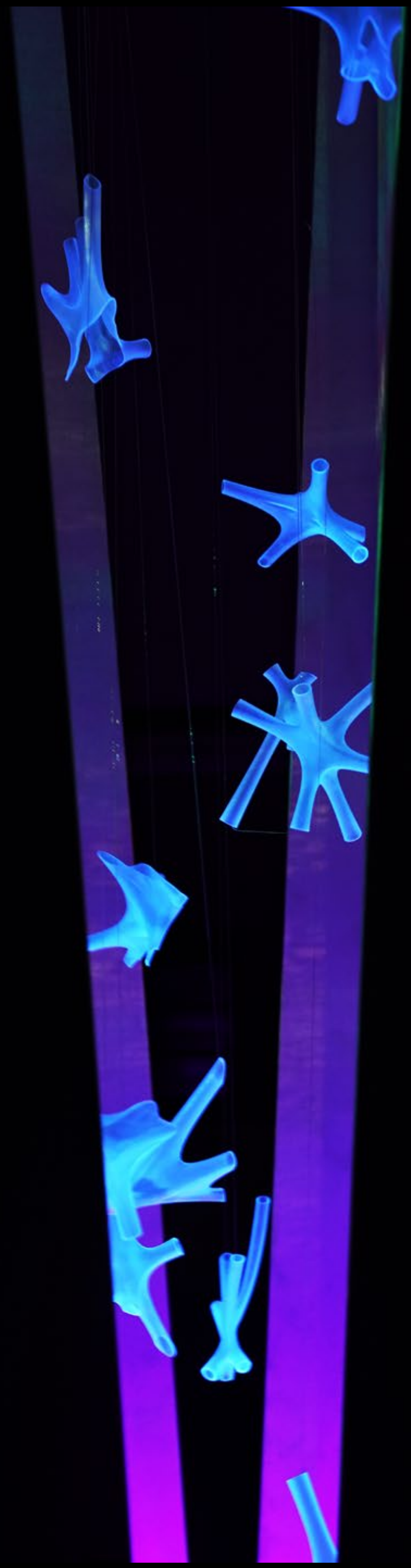
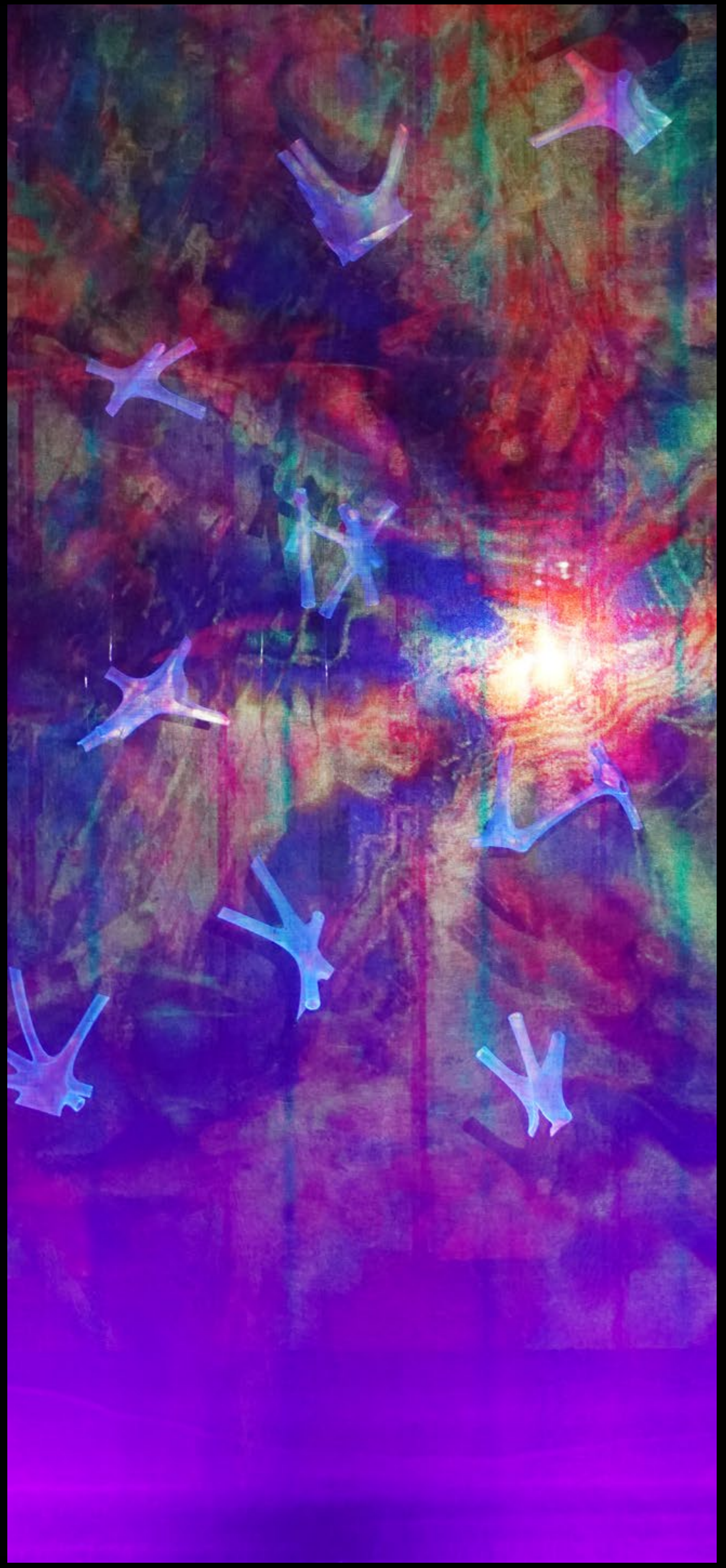
ITERATION 02 ITERATION 03



+ PROJECTION ARCHIVE





\+ **CONCLUSION**

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This research engages MORPHOGENESIS as a material and conceptual framework for the exploration of hybridized architectural systems in response to extreme climatic conditions. From studying biological precedents, to examining their integration with artificial fabrication methods, this proposal offers a speculative, yet research-driven approach to adaptable, resilient design. By utilizing hybridized materials, derived from natural growth patterns and engineered structures, demonstrates the potential for rethinking building envelopes. By utilizing science-fiction references and visual strategies, the research was able to expand the scope of architectural design, encouraging engagement with the uncertain, transitional design, and survival capabilities. MORPHOGENESIS ultimately asserts itself as a prototype for how architecture can work in tandem with shifting environments and biological networks. By serving as a model for a hypothetical, interdisciplinary approach, it can further inform research in material innovation and specialization within an increasingly unstable world.

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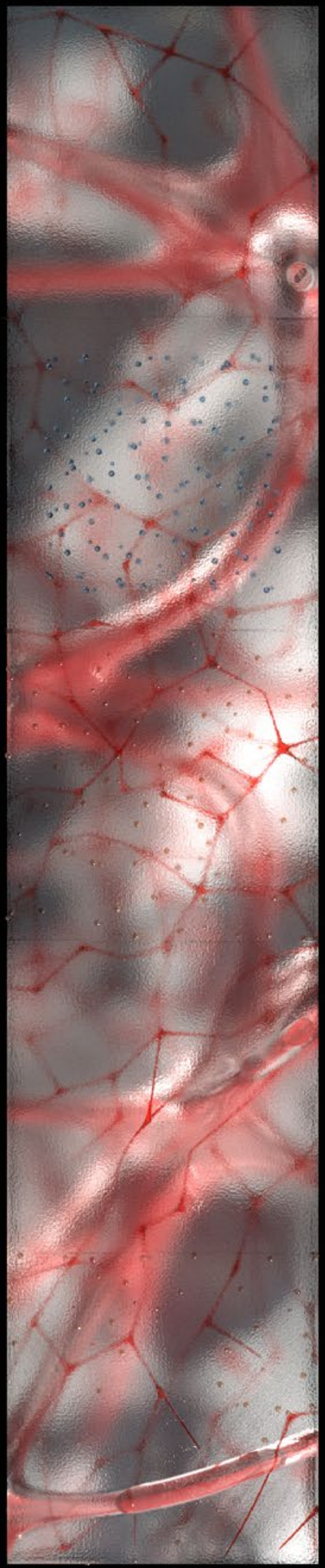

+ REFERENCES

1. “Sendai Mediatheque – Toyo Ito.” Steel Explained. Accessed April 26, 2025. https://steelexplained.com/day-293-365-of-steel-sendai-mediatheque/.

2. “Sports Hall La Minais – Bohuon Bertic Architectes.” Archello. Accessed April 26, 2025. https://archello.com/project/sports-hall-la-minais.

3. “Agency GIBOIRE Morbihan Offices – a/LTA.” ArchDaily. Accessed April 26, 2025. https://www.archdaily.com/959367/agency-giboire-morbihan-offices-a-lta.

4. Ashby, Michael F. Materials Selection in Mechanical Design. 4th ed. Oxford: Butterworth-Heinemann, 2011.

5. “Translucent Concrete.” Arquitectura Viva. Accessed April 26, 2025. https://arquitecturaviva.com/articles/translucent-concrete.

6. “Metallic Foams.” Filter Elements. Accessed April 26, 2025. https://www.filter-elements.org/filter-elements/metallic-foams.html.

7. “What is Fiber Reinforced Concrete – Different Applications, Benefits and Types.” Premier Precast. Accessed April 26, 2025. https://premierprecast.com/glass-fiber-reinforced-concrete/.

8. “Cricket Shelter.” Terreform ONE. Accessed April 26, 2025. https://www.terreform.org/cricket-shelter.

9. “Voromuro.” NADAAA. Accessed April 26, 2025. https://www.nadaaa.com/portfolio/voromuro/.

10. “Fiberbots.” MIT Media Lab. Accessed April 26, 2025. https://www.media.mit.edu/projects/fiberbots/overview/.

11. Ma, Peter X. “Scaffolds in Tissue Engineering Bone and Cartilage.” Proceedings of the National Academy of Sciences of the United States of America 105, no. 32 (2008): 12222–12223. https://pmc.ncbi.nlm.nih.gov/articles/PMC2587658/.

12. “Transplantation of Chondrocytes Utilizing a Polymer-Cell Construct to Produce Tissue-Engineered Cartilage in the Shape of a Human Ear,” Plastic and Reconstructive Surgery 100, no. 2 (1997): 297–302. https://doi.org/10.1097/00006534-199708000-00001.

13. “Vespers II.” Oxman.com. Accessed April 26, 2025. https://oxman.com/projects/vespers-ii.

14. Druckmann, Neil, and Bruce Straley. The Last of Us. Developed by Naughty Dog. Released on PlayStation 3. Sony Computer Entertainment, 2013.

15. Kojima, Hideo. Death Stranding. Developed by Kojima Productions. Released on PlayStation 4. Sony Interactive Entertainment, 2019.

16. Boucard, Kristina, and Bruno Samper, directors. Vesper. Directed by Kristina Boucard and Bruno Samper. Belgium: Versus Production, 2022.