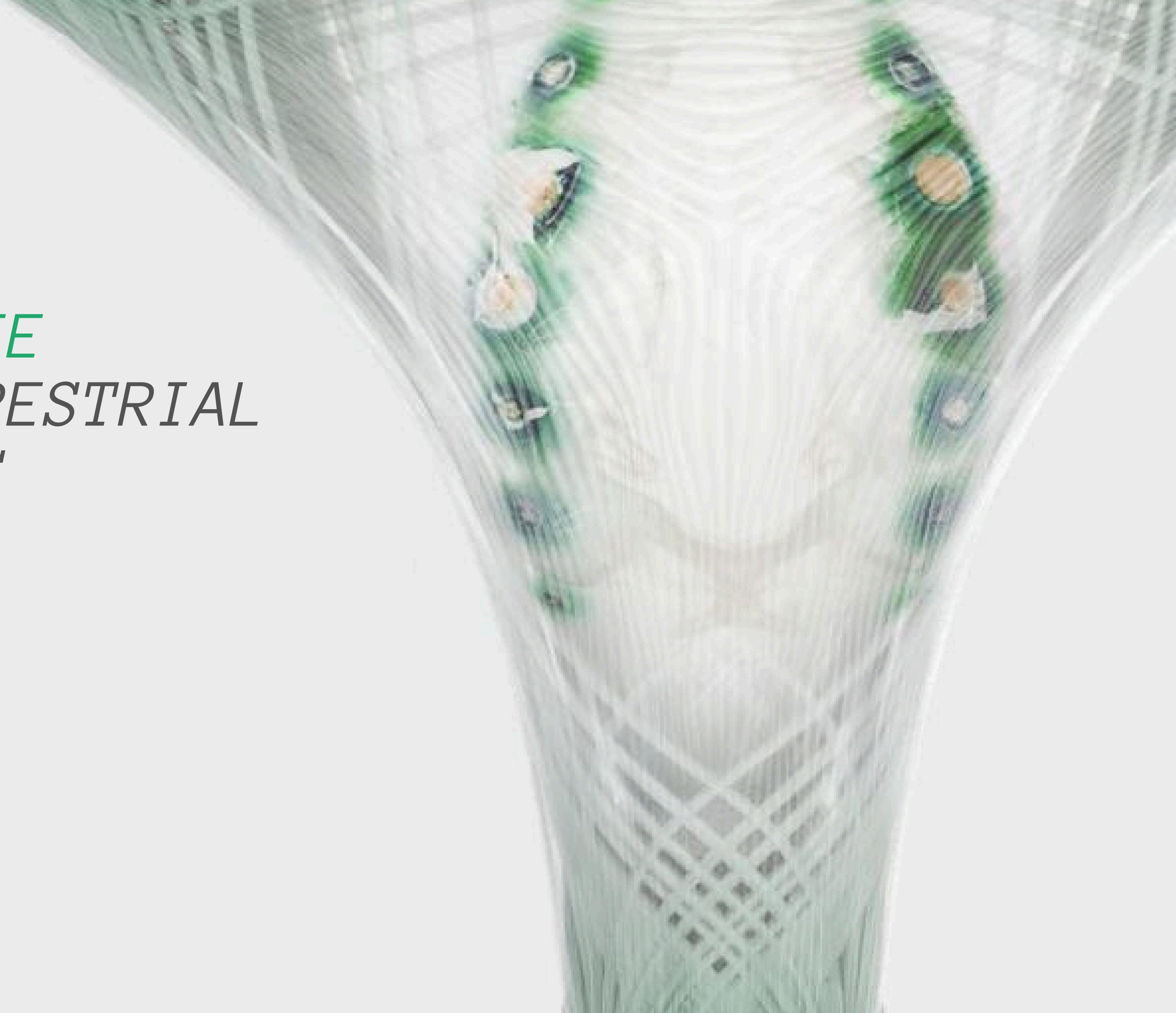
BRINGING LIFE TO EXTRATERRESTRIAL ENVIRONMENTS

HYBRID LIVING MATERIALS



BiO2 Platform

CONTEXT ALIGNMENT

NASA Habitat Technical Framework

Human life for long-duration missions under strict constraints on volume, mass, safety, and maintainability

- Use of sustainable materials, possibly produced via in-situ resource utilization (ISRU) or bio-based regeneration systems.
- Life support (oxygen regeneration, CO_2 removal, humidity & thermal control).
- Radiation protection against solar and galactic cosmic rays.
- Structural integrity under low external pressure (~610 Pa on Mars) and internal pressure (~8.3 psia).
- Modular scalability for transportation and in-situ assembly.

Our project aligns with these objectives by proposing **a Bio² Hybrid Living Material System**—a modular **hydrogel-algae-elastomer composite** that integrates life support, radiation shielding, and self-sustaining maintenance within the habitat envelope.

Future Goal

Post-Anthropocene

GOAL

Sustainable future

Exploring post-Anthropocene and the **possibilities of life for all species:**

How might we design systems and environments that enable **humans, plants, microbes, and other organisms to co-exist**, adapt, and thrive together—extending **life beyond Earth and rethinking the boundaries of what it means to live? - envisions a future where life in all its forms can flourish in harmony**

PROBLEM ANALYSIS

System Function	Current Challenge	Bio2 Solution
Radiation Shielding	Lightweight Habitats Need ›S G/Cm? Shielding For <50 MSv/Year; Conventional Polymers Degrade Under Radiation.	Water-Rich Hydrogel (~1.05 × 10- Kg/Mm°) Absorbs Neutron And Ionizing Radiation; Algae Regenerate Water And Organic Mass
Atmospheric Regulation	COz Buildup And O2 Shortage In Closed Systems; Mechanical ECLSS Consumes High Energy.	Photosynthetic Algae Convert CO2 - O2, Reducing Mechanical Load; Sensors Monitor Gas Balance In Real Time
Structural Efficiency & Pressure Resistance	Inflatablo Habitats Must Handle ~8. 3 Psia Internal Vs 0.6 KPa External Pressure With Low Mass	Multi-Layer Sandwich Plate With Variable Stiffness And Y-Truss Reintorcement; Joints Meet NASA F3 2 4 Satety Factor.
Thermal Control	Temperature Swings (150-300 K) Cause Material Strain And Instability.	Hydrogel Provides Thermal Damping: Elastomer Skeleton Convensales Expansion, Protecane Miner Layers
Modularity & Assembly	Robotic Assembly On Mars Is Complex And Error-Prone	Standardized, Portable BiO? Modules Enable Fast, Robot-Compatible Assembly (Class II Prefabricated/ Inflatable).
Resource Limitation / ISRU	Transporting Shielding And Consumables Is Costly.	Hydrogel Synthesized In-Situ From Regolith-Derived Water And Nutrients; Algae Cultivated Locally.
Psychological Well-Being	Isolation And Monotone Interiors Harm Mental Health.	Living Bio-Luminous Walls Add Color, Motion, And Biophilic Comfort, Improving Crew Morale.

STEEP

SOCIAL

Water Party

Black Market

AI Robot

Young people(0-19s)

International cooperation

Totalitarianism

TECHNOLOGY

Protect radiation

Bio-based material

Transport material to Mars

Creating energy on Mars

AI for Mars

3D print building

ECONOMY

Day time/Midnight

Government founded

Equally divide resources(water, food, house)

ENVIRONMENT

Radiation

Sun belief

Low gravity

living in North Area

//New material

Sustainable material,

self recovering, self sustaining

Limited living space & useful resources

POLITICS

AI simulation model

Laws to protect country's patent

Regulation

Every person have their own mission

SIGNALS

Totalitarianism

Bio-based material

Creating energy on Mars

3D print building

Equally divide resources(water, food, house)

Sustainable material

Limited living space & useful resources

USER JOURNEY

	ONBOARDING & SETUP	FIRST ACTIVATION	MAINTENANCE	SOCIAL ENGAGEMENT	REST & REFLECTION
Activity	Unpack modules Hydrate hydrogel Inoculate algae Calibrate sensors	Start gases cycle Monitor light response Test pressure & shielding	Replace gel layers Cycle water & nutrients Log system data Evaluate long-term data	Archive ecosystem evolution Share data Train crew Coordinate bio-tech ops	Resting alone Interacting with others Observe bioluminescence
Places	Setup Bay	Core Chamber	Bio-Lab	Common Hub	Private Zone
Pain Points	Low gravity Unclear assembly steps Delayed algae activation	Unclear feedback from algae/photosynthesis metrics. Anxiety over oxygen levels meeting crew needs.	Overlapping systems creating interface errors Complex controls	High risk in modifying genetic or hydrogel parameters Coordination gaps	Lack of Privacy Limited Space

HOW MIGHT WE

BIO2

How might we design a **BiO2 Generation System** that enables a **symbiotic ecosystem** where **both humans and living organisms**—including bacteria, plants, and other microbes—can co-exist, interact, and thrive through **bioengineered materials** that support mutual growth, adaptability, and resilience in extraterrestrial environments like Mars?

MATERIAL

What is Hydrogel?

- Material

  PEG

  PAM

  Gelatin

  .etc

- Characters

  Lightweight and flexible → **Portable assembling**

  Strong neutron shielding → **Radiation-protective**

  High formability for use → **Customized design**

How is using in 2025 ?

- Biomedical

  Neural Tissue Repair

  Bone tissue repair

  Biomonitoring

- Building

  Purify the air

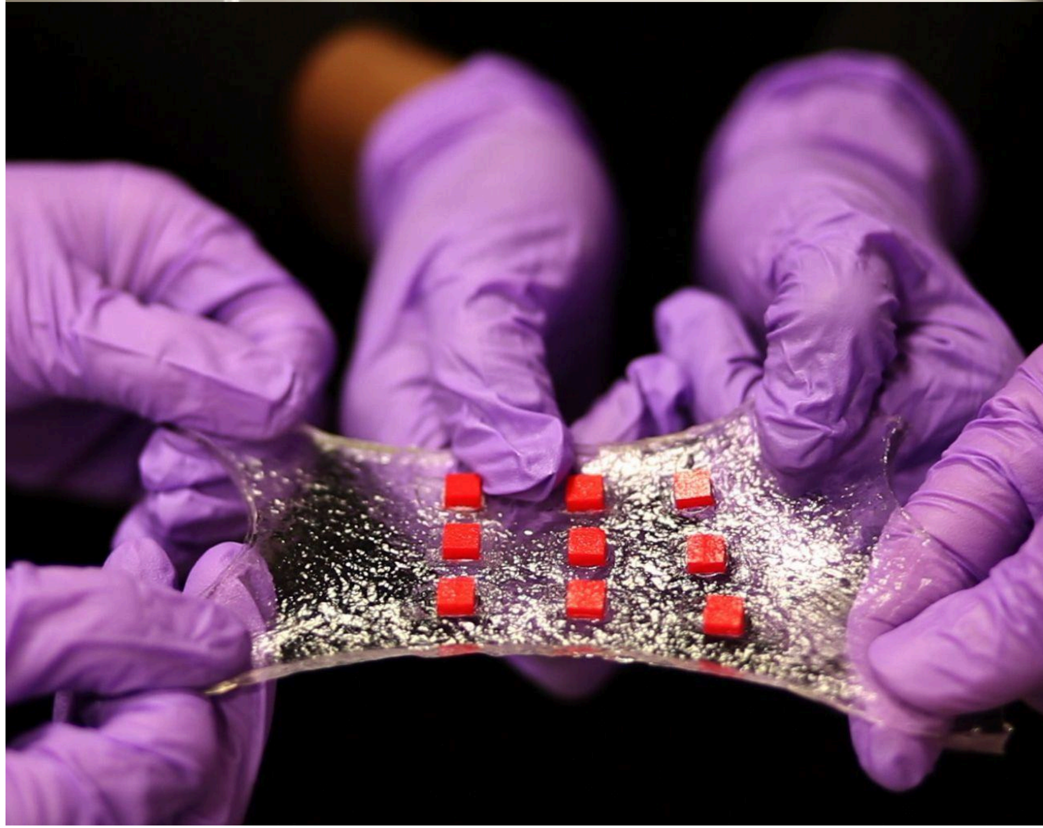
  Sustainable construction

  Algae-Laden Hydrogel Could Bring Buildings to Life

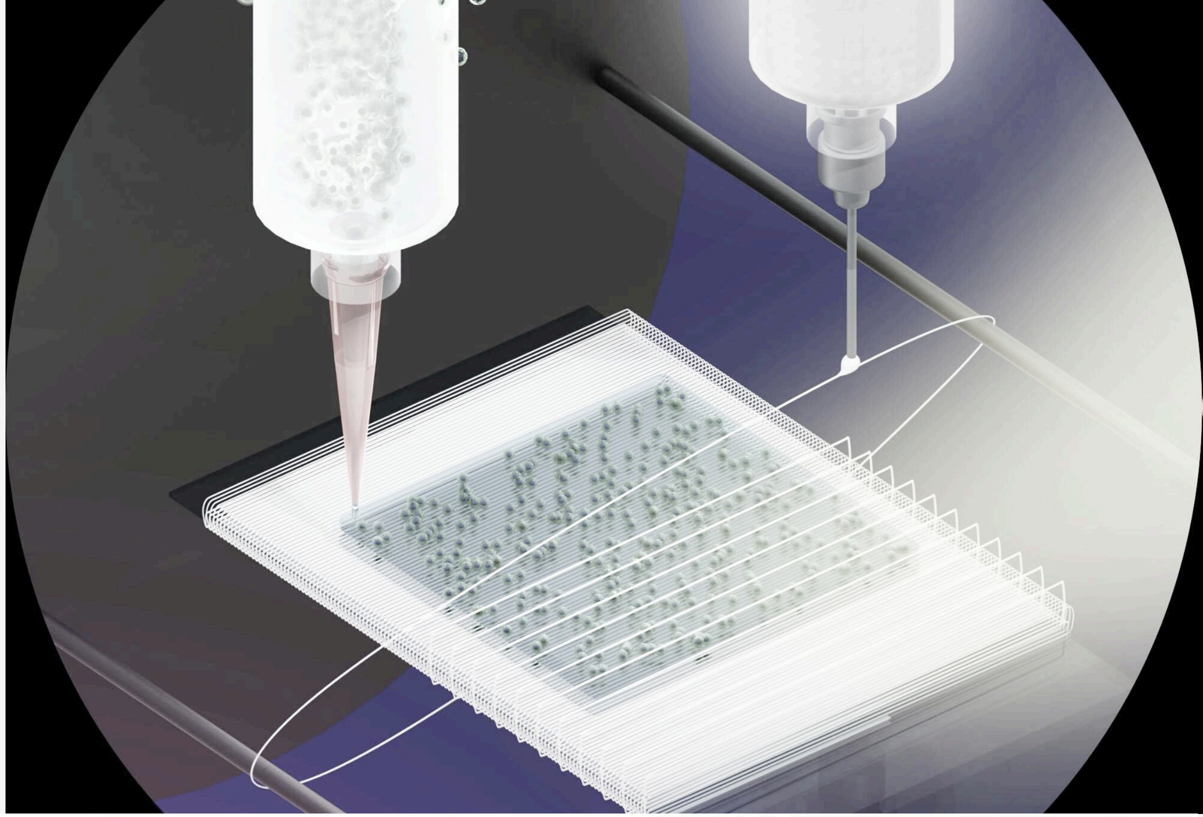
Reference:

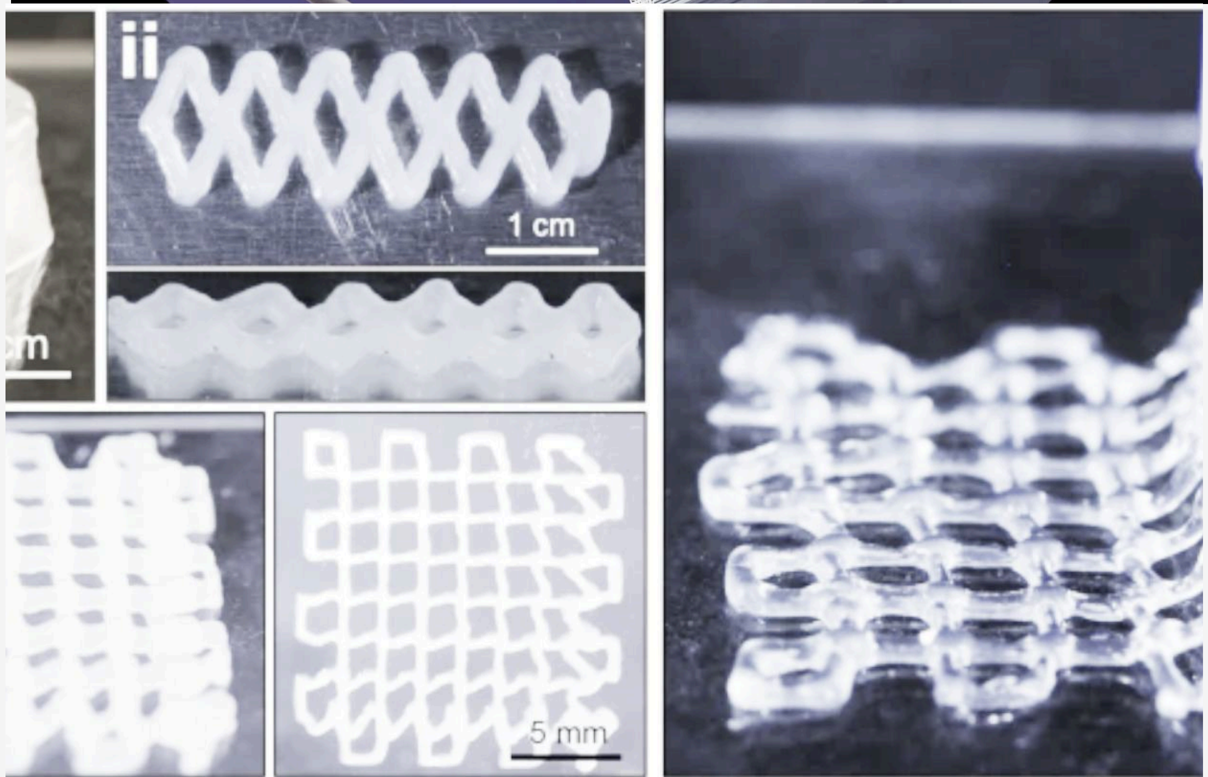
Biopharma. *"Top 10 Applications of Hydrogels in Biomedical Field | Biopharma PEG."* Www.biochempeg.com, 28 Jan. 2022, www.biochempeg.com/article/244.html.

Malik, Shneel, et al. "Robotic Extrusion of Algae-Laden Hydrogels for Large-Scale Applications." *Global Challenges*, vol. 4, no. 1, Nov. 2019, p. 1900064, https://doi.org/10.1002/gch2.201900064. Accessed 2 Nov. 2021.



PRODUCT OVERVIEW





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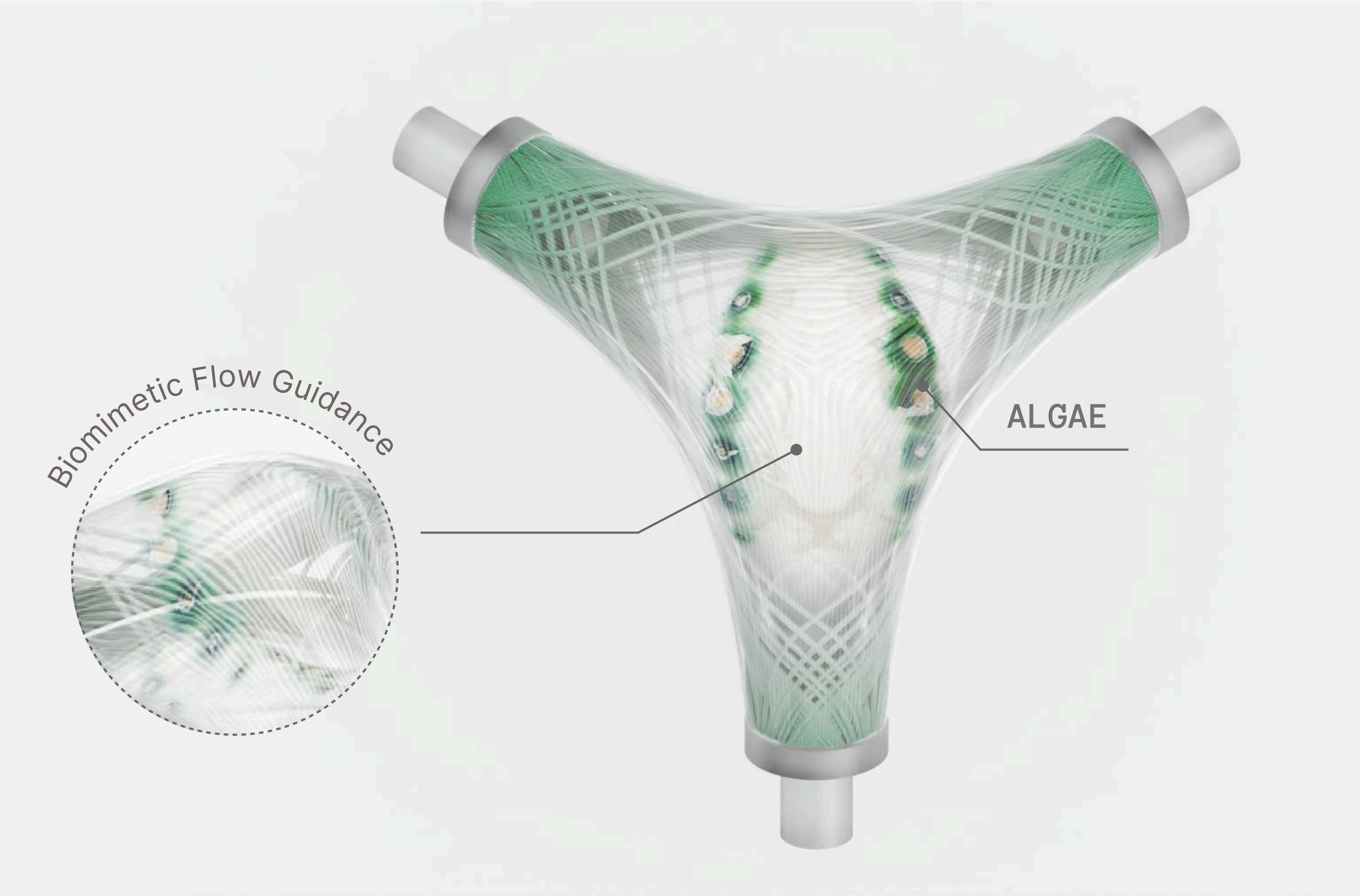

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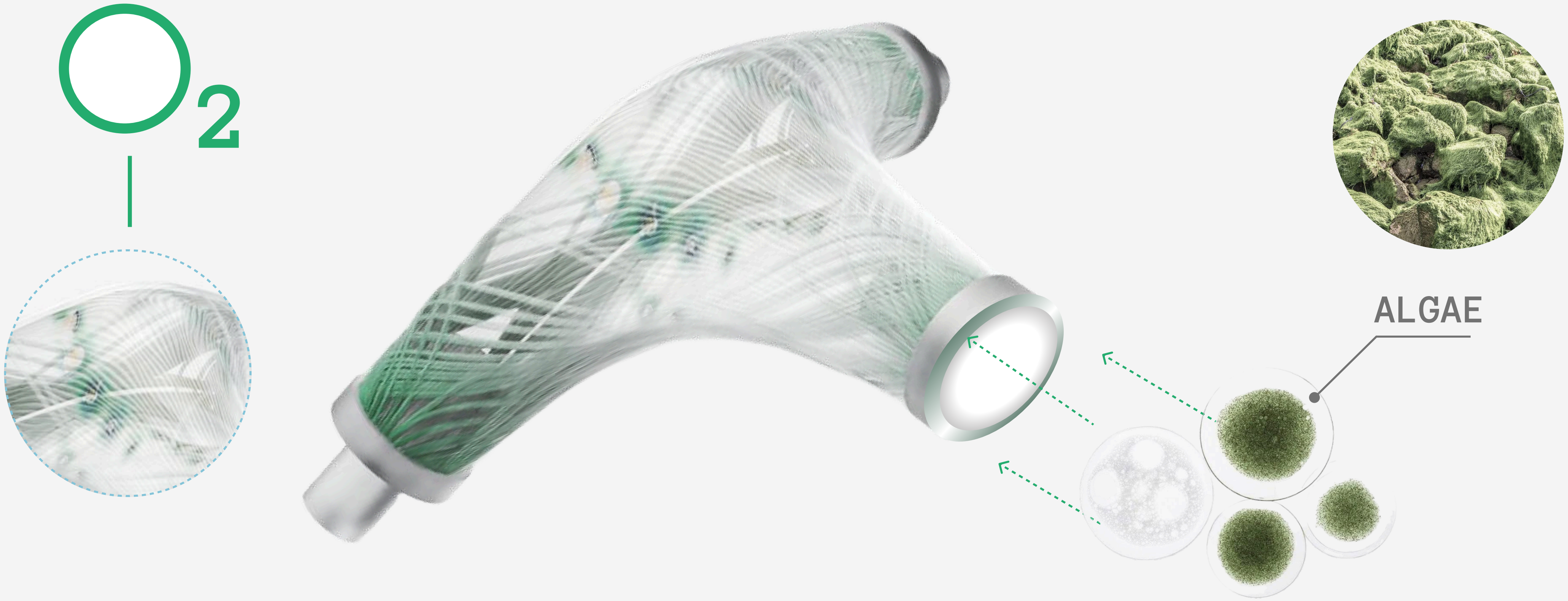

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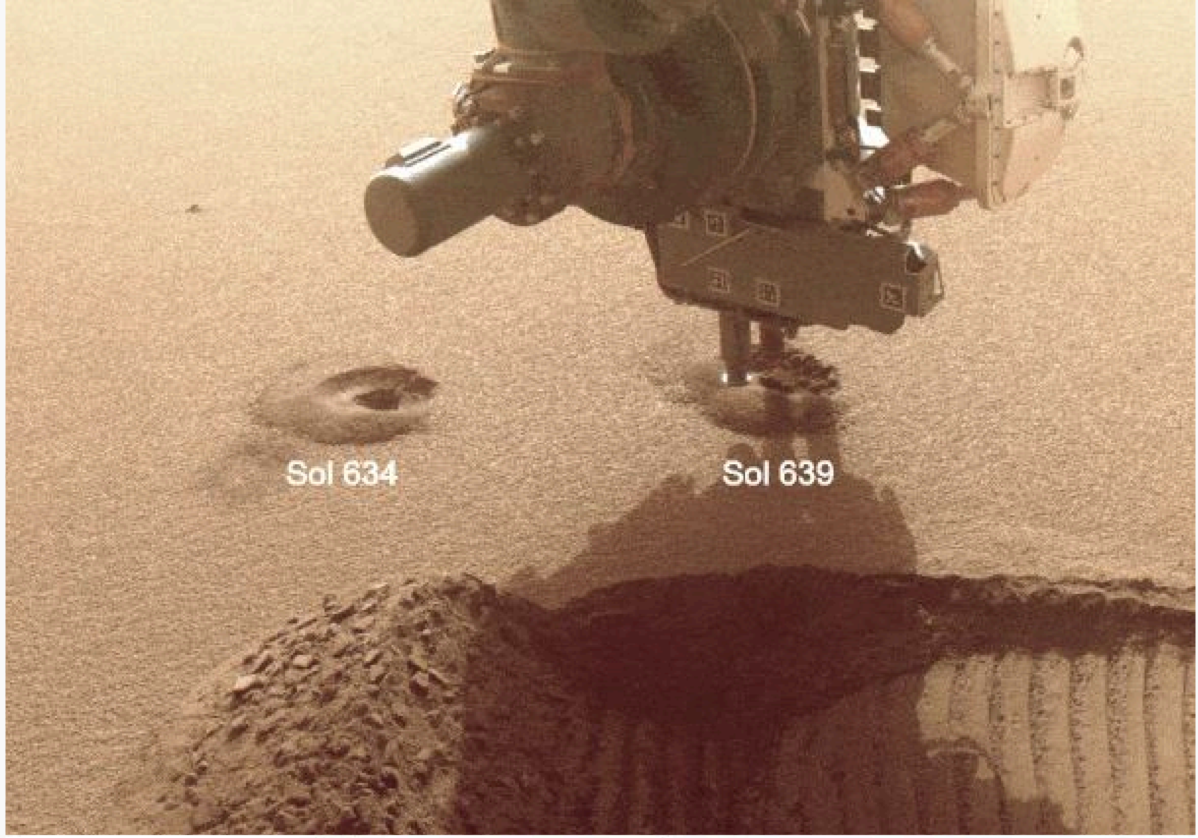
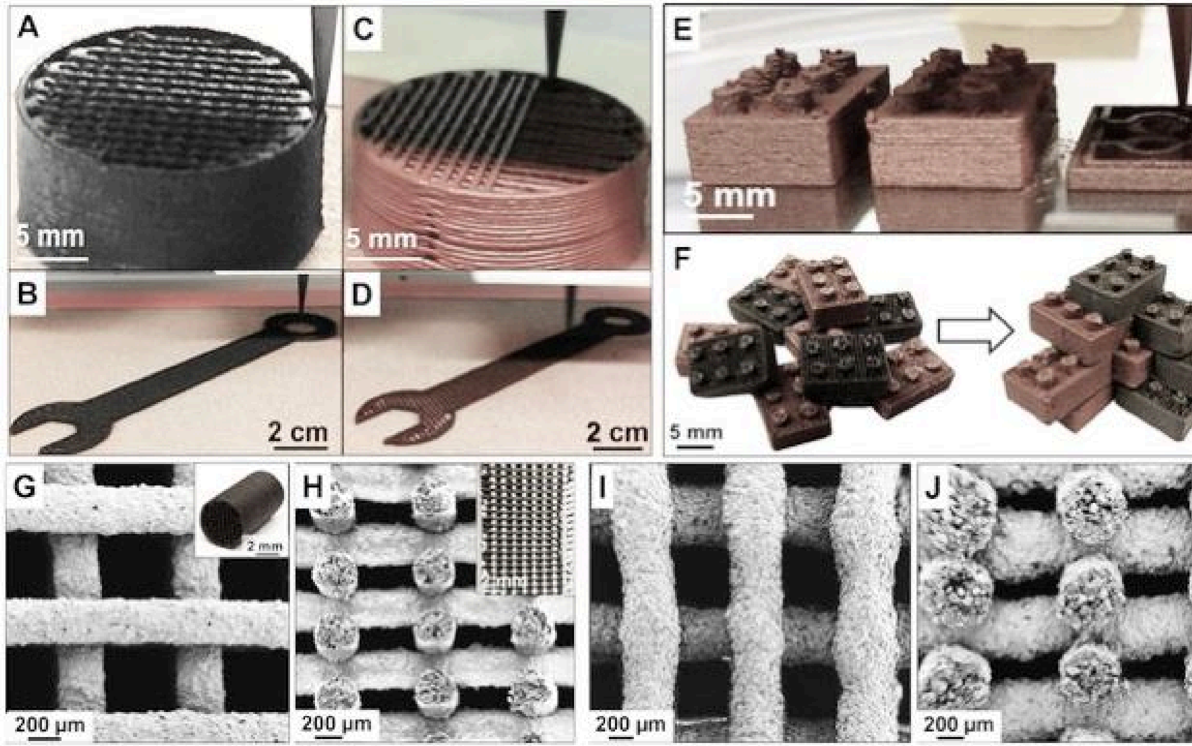
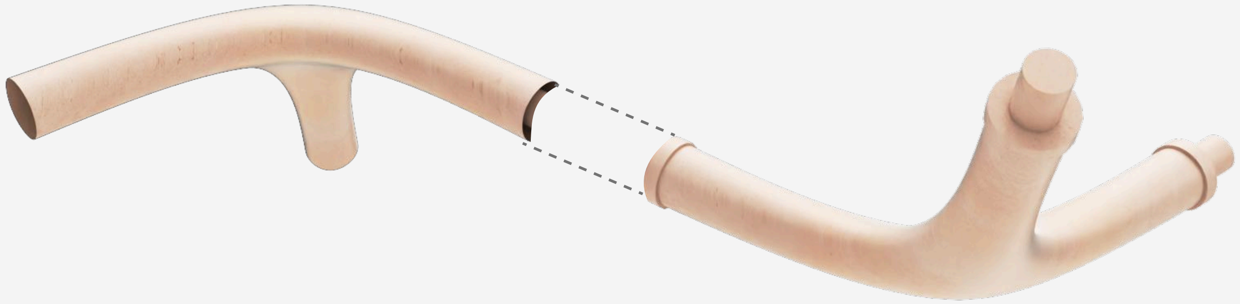




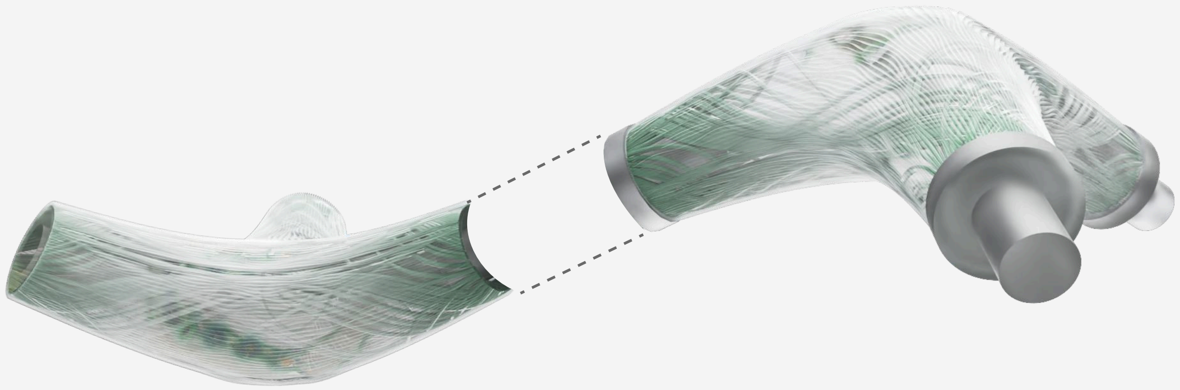
PRODUCT OVERVIEW

SKELETON



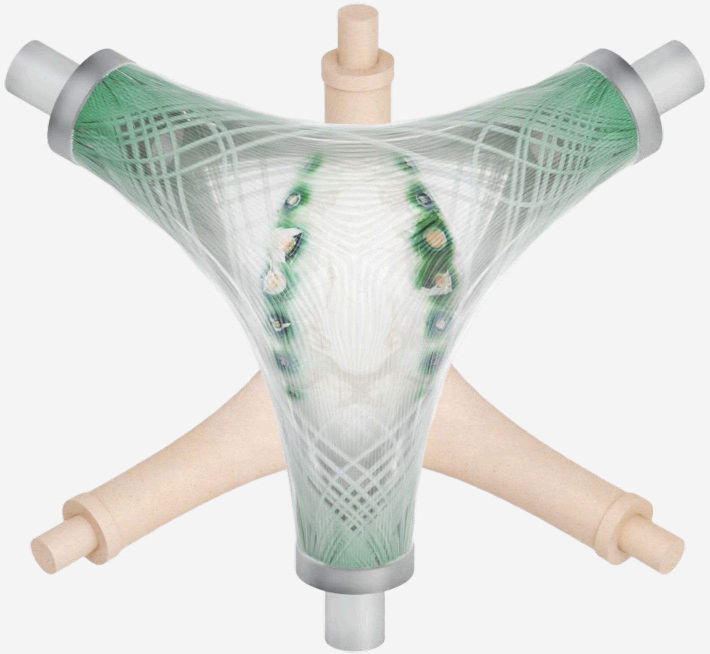
CONNECTING

HYBRID LIVING MATERIAL

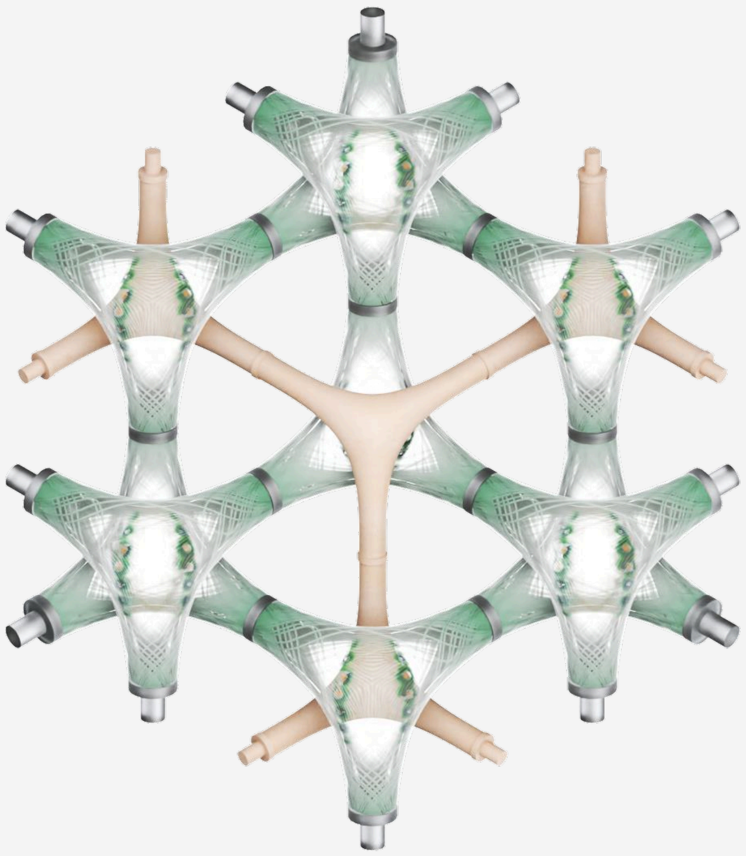


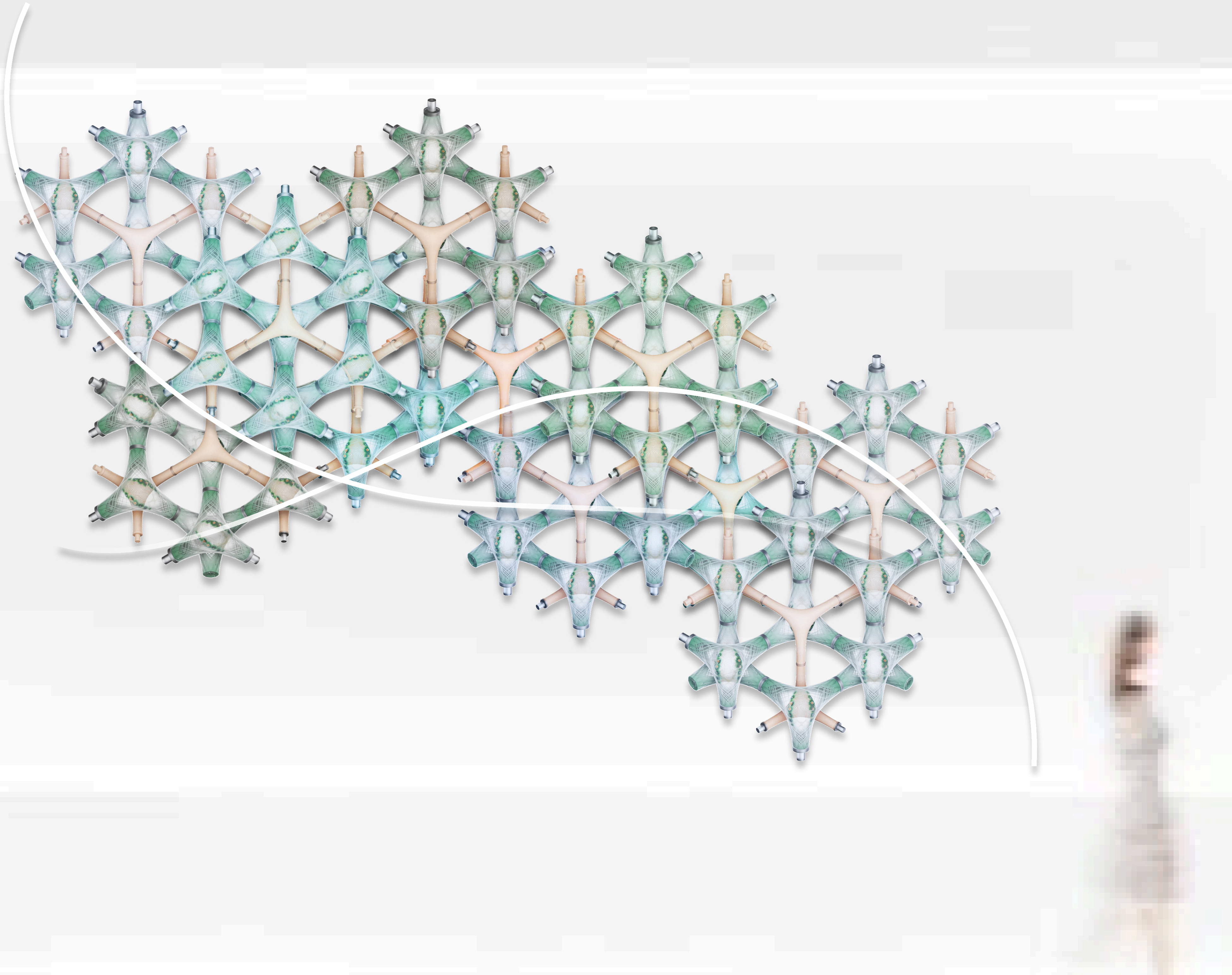
PRODUCT OVERVIEW

MODULAR

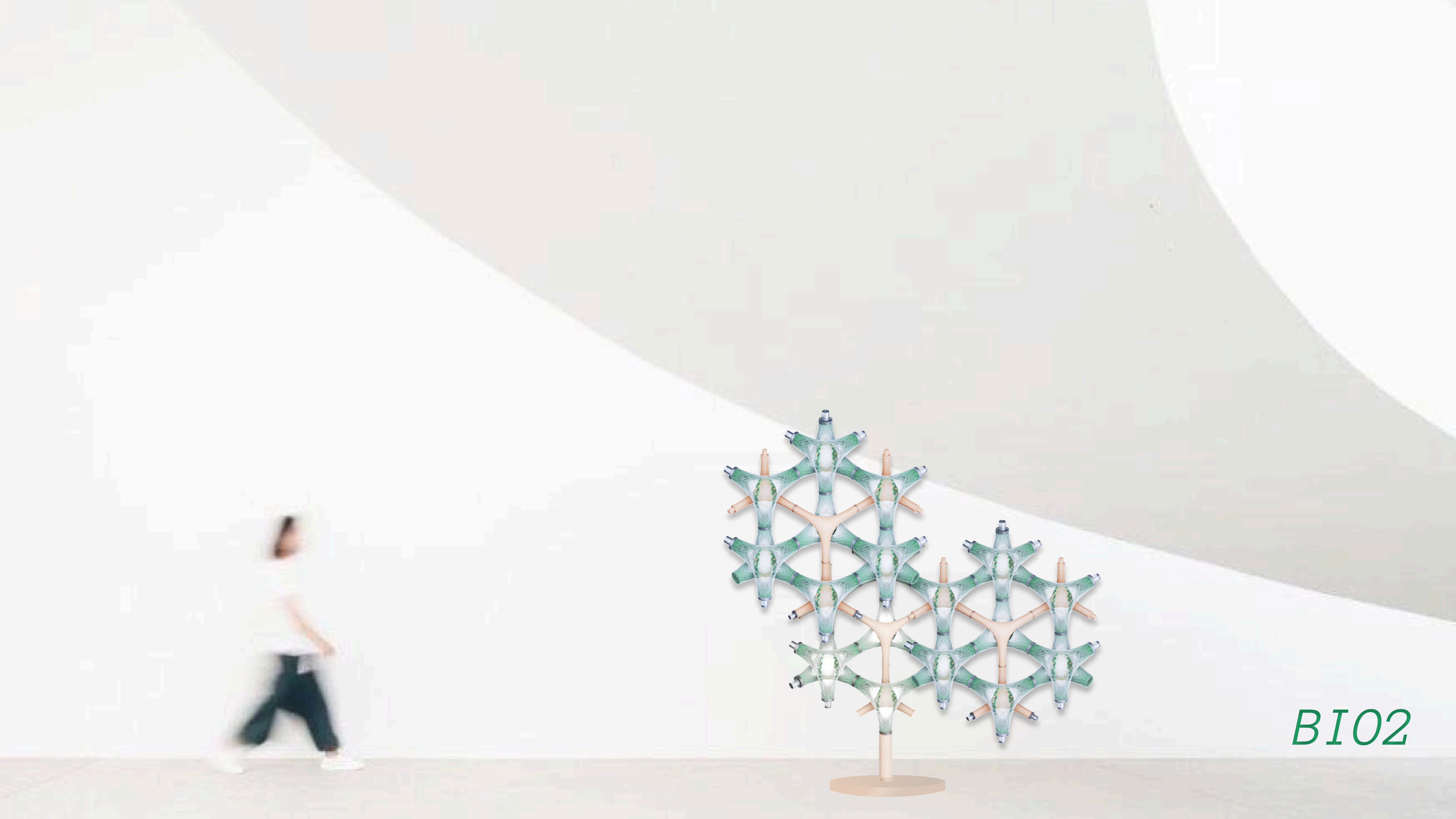


SYSTEM

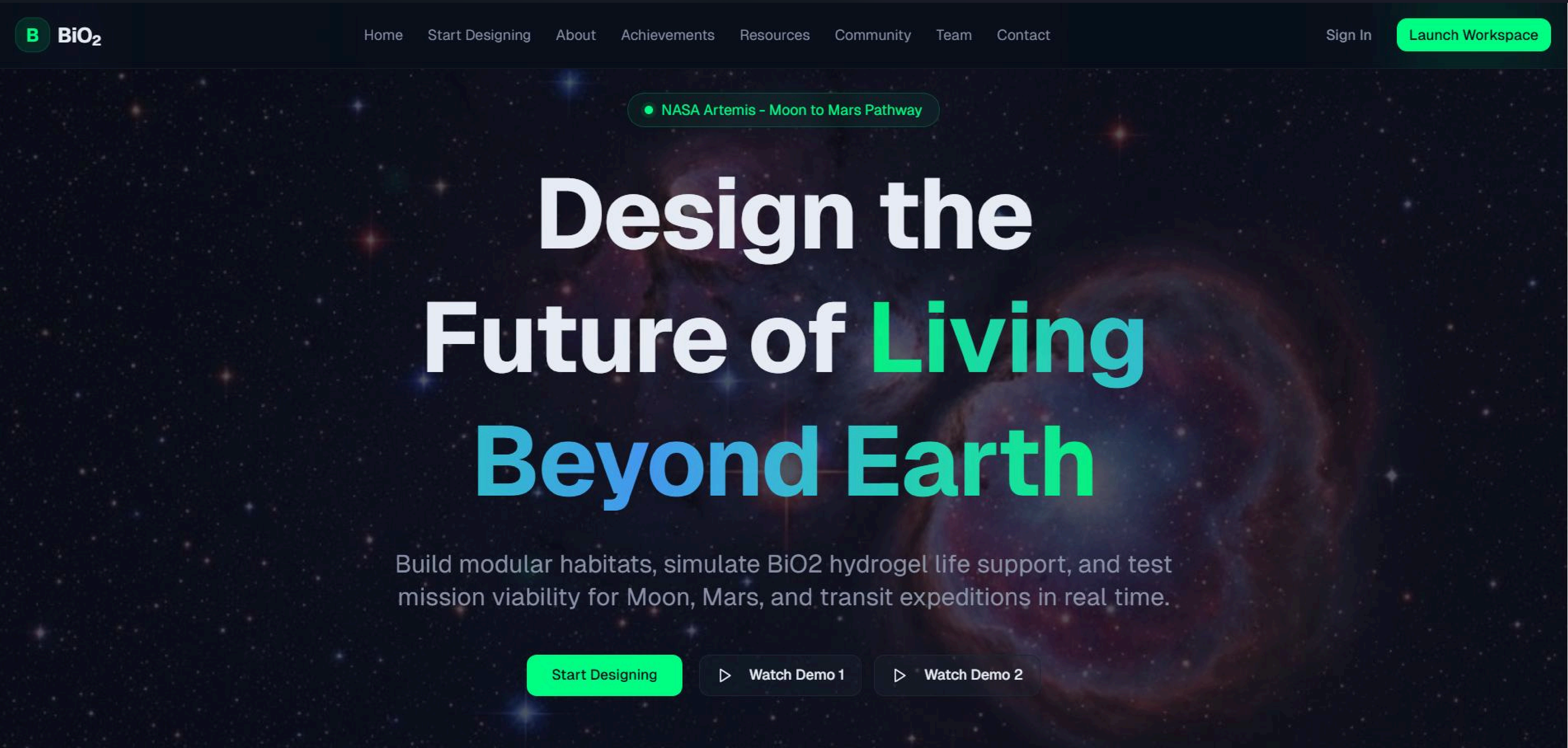




BIO2


BIO2

BIO2 Platform



BIO2 Platform

Everything You Need to Design Space Habitats

Professional-grade tools for students, engineers, and explorers
to imagine resilient Moon, Mars, and deep-space habitats.

BiO2 Modules

Algae and hydrogel units that generate oxygen, recycle water, and deliver passive radiation shielding.

Habitat Layout Tool

Drag-and-drop builder with snap-to-grid precision, 2D floor plans, and immersive 3D structure views.

Simulation Engine

Live telemetry tracks oxygen balance, hydrogel health, crew comfort, thermal envelopes, and structural loads.

Mission Viability

Automated scoring highlights shielding effectiveness, resource margins, redundancy, and safety factors.

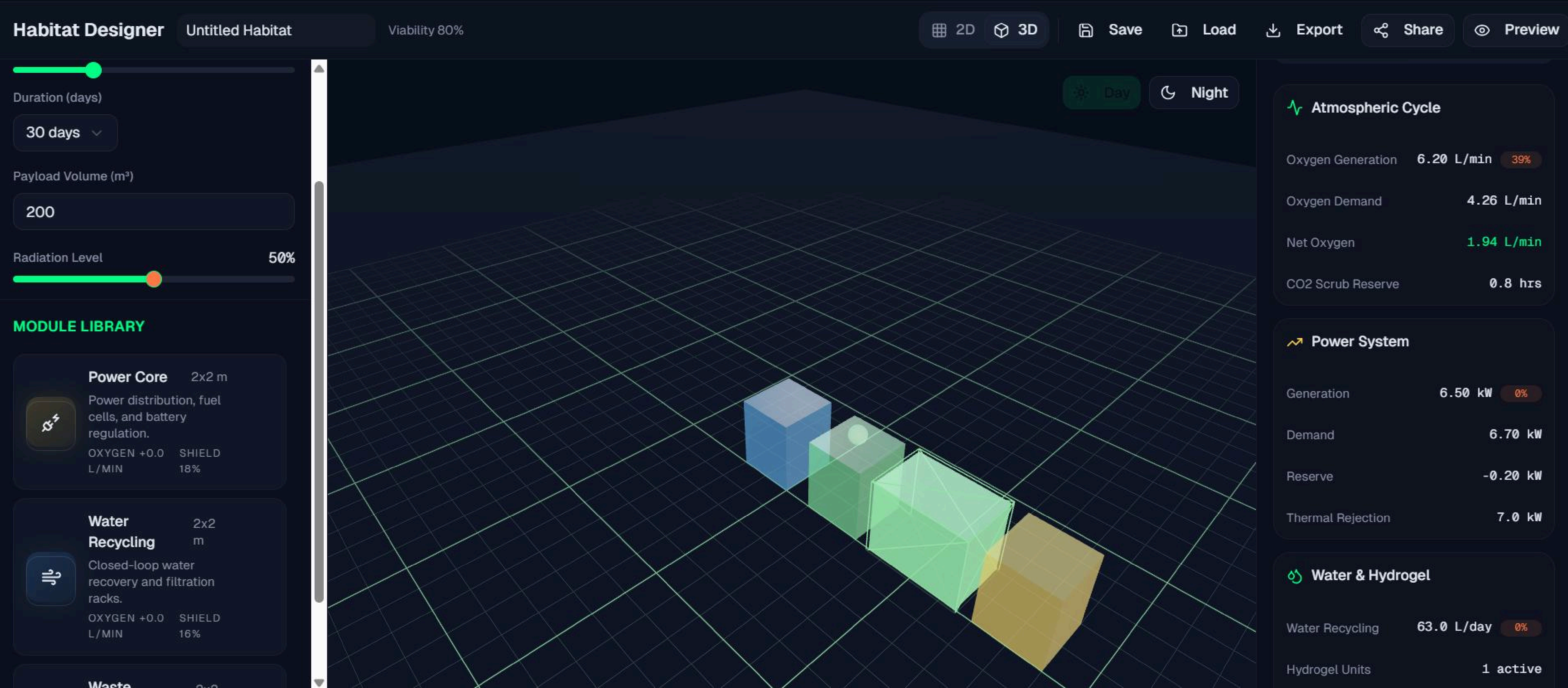
Community Sharing

Publish, remix, and collaborate on habitat concepts with the BiO2 community gallery and design badges.

3D Printing Function

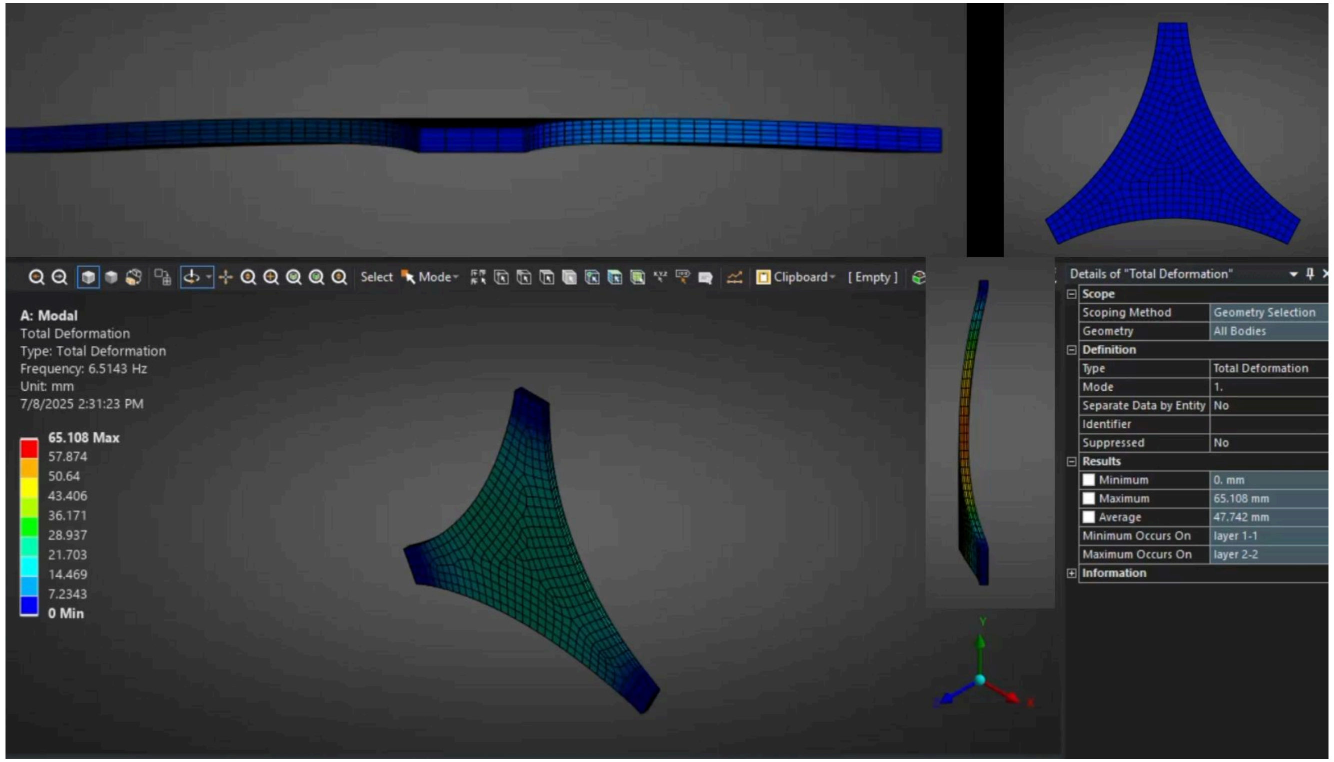
Using locally available materials at the exploration site to print BiO2-based structures via a 3D printing robot.

BIO2 Platform – Main Feature



DESIGN / MATERIAL STRUCTURAL ANALYSIS

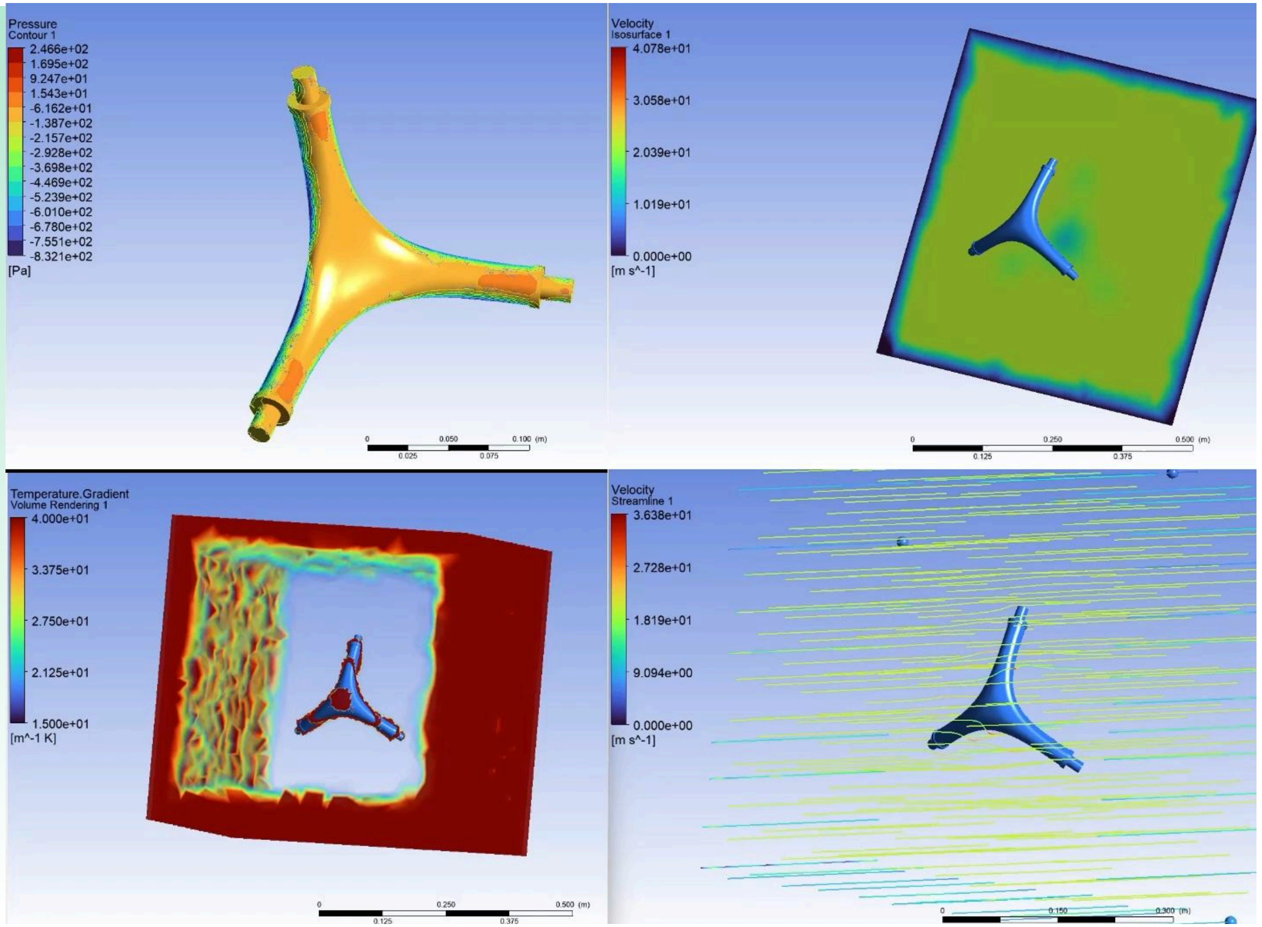
Property	Main Layer	Layer 1-1 / 2-1	Layer 1-2 / 2-2
Density (kg/mm³)	1.05×10^{-6}	1.10×10^{-6}	1.15×10^{-6}
Young's Modulus (MPa)	0.02	0.5	5.0
Poisson's Ratio	0.49	0.485	0.48
Bulk Modulus (MPa)	0.333	5.556	41.667
Shear Modulus (MPa)	0.0067	0.168	1.689



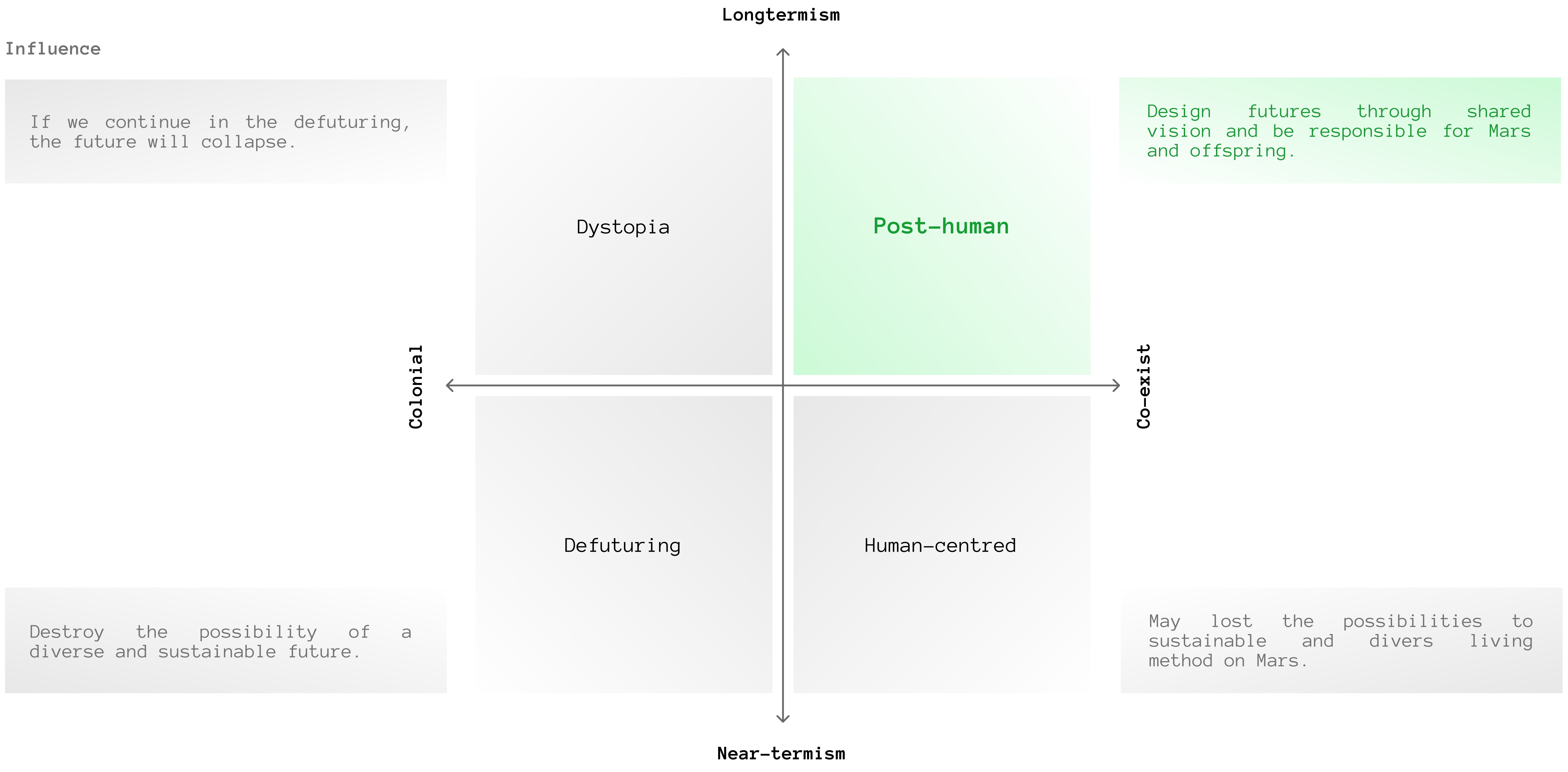
The sandwich plate is designed with increasing stiffness from core to outer layers, ensuring both structural strength and a protected inner environment for bacteria.

DESIGN / STRUCTURAL ANALYSIS

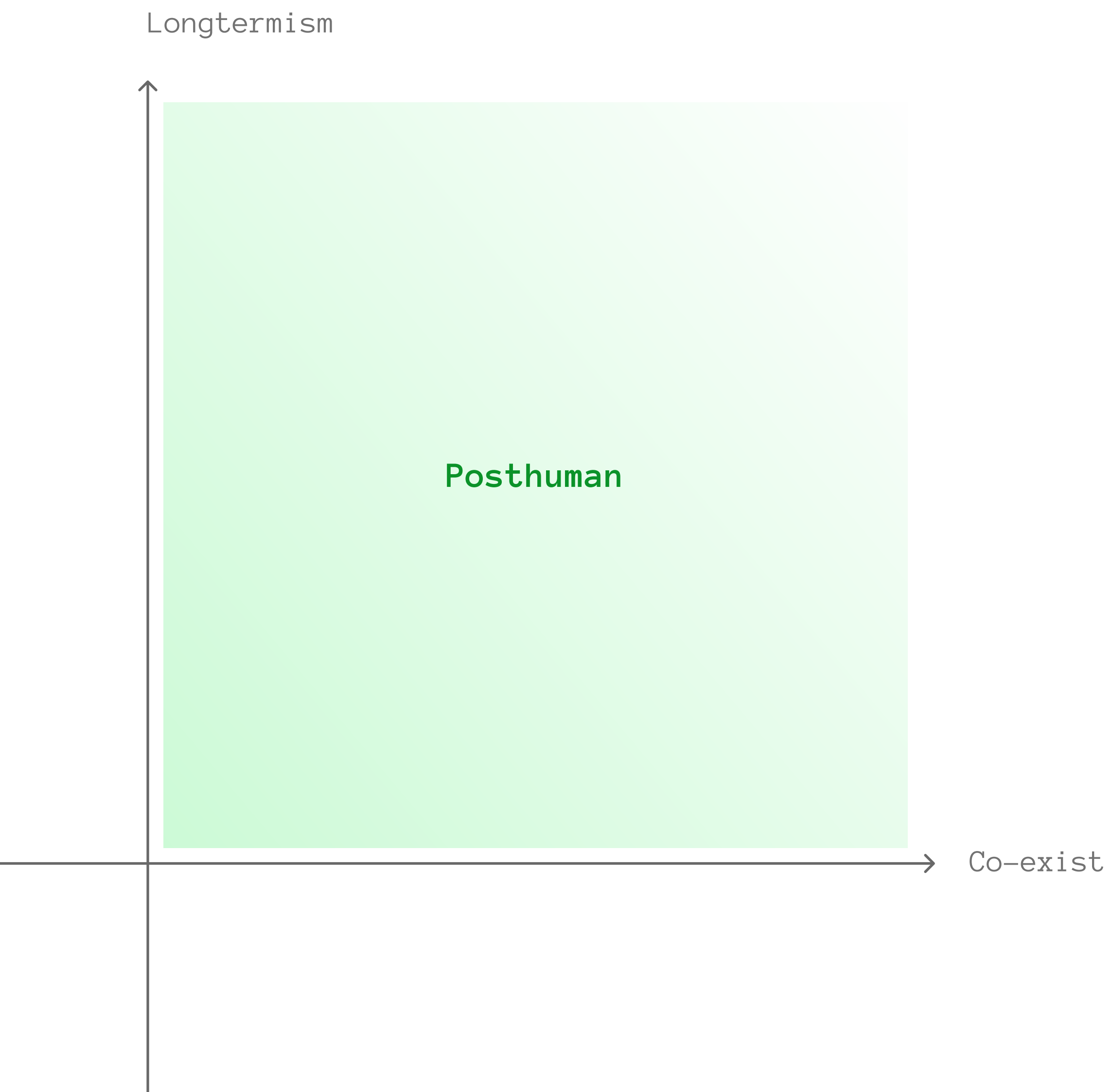
- **Design:** Y-branched truss supports the sandwich plate and preserves space for the core layer
- **Pressure:** Resists ~610 Pa Martian pressure; stress concentrated at junctions → needs reinforcement
- **Velocity:** Simulated up to 30 m/s; streamlined form reduces flow separation and drag
- **Thermal:** Operates across 150–300 K; truss remains stable, but thermal strain at nodes must be considered



SCENARIO


Longtermism
Influence
If we continue in the defuturing, the future will collapse.
Dystopia
Post-human
Design futures through shared vision and be responsible for Mars and offspring.
Colonial
Co-exist
Defuturing
Human-centred
Destroy the possibility of a diverse and sustainable future.
May lost the possibilities to sustainable and divers living method on Mars.
Near-termism

SCENARIO



How our design trying to reach the Posthuman in the future?

Safety

Radiation Shielding by Hydrogel

The bio-hydrogel serving as the shell of the architectural modules, utilizes its water-containing properties to effectively absorb and shield radiation, thereby establishing a key safety barrier for the inhabitants.

Biology

Integrated Algae System

Algae are cultivated within the structure of the hydrogel. These living materials can consume carbon dioxide and continuously generating oxygen.

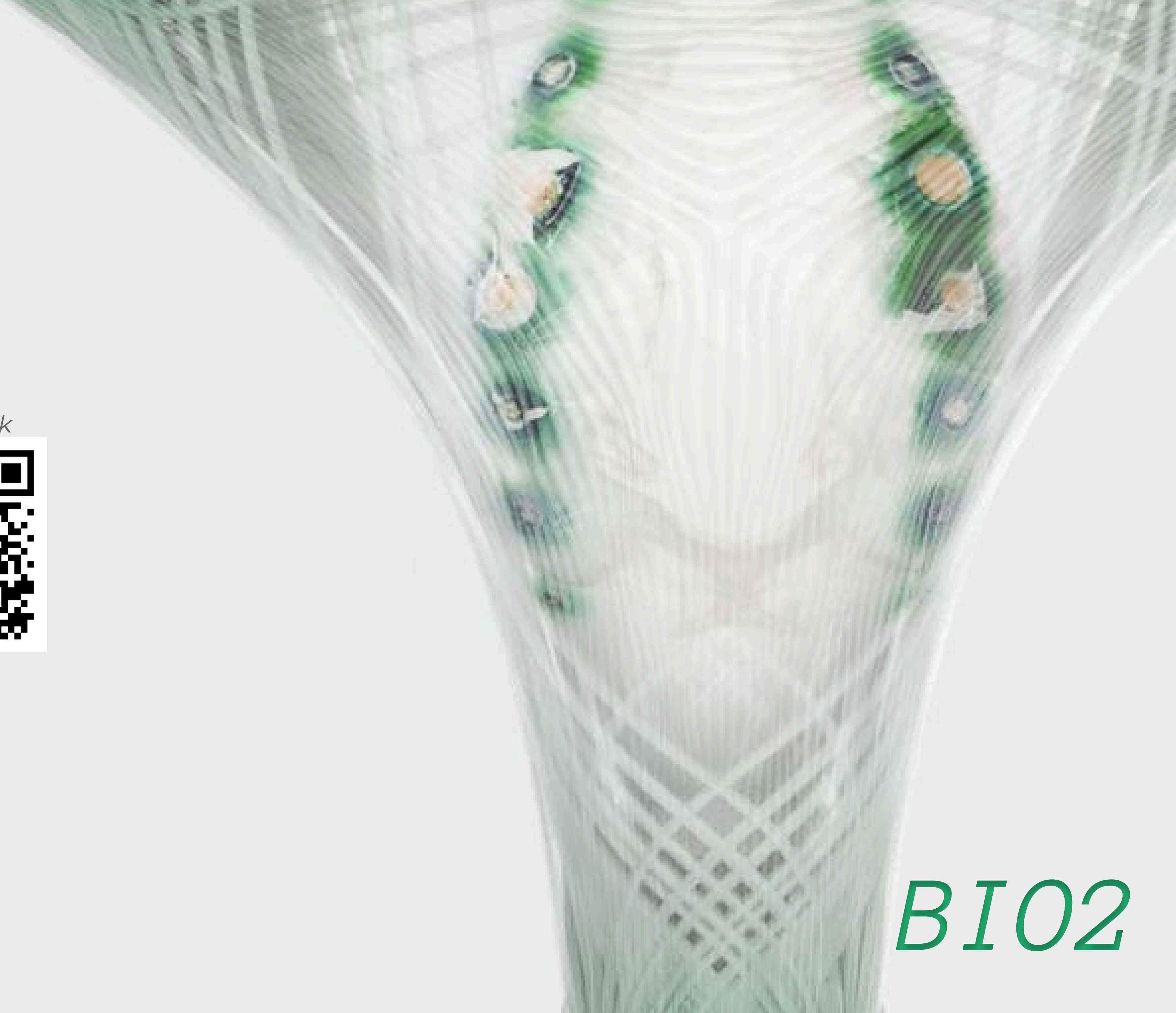
Sustainability

Modular Construction

The Bio² system is based on standardized, assemblable modules. This design makes the habitat's construction process efficient, flexible, and scalable, meeting the long-term needs for the sustainable development of a Mars base.

Website Link

GitHub Link



BIO2