



# *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.

Structural integrity under low external pressure (~610 Pa on Mars) and internal pressure (~8.3 psia).

Life support (oxygen regeneration, CO<sub>2</sub> removal, humidity & thermal control).

Modular scalability for transportation and in-situ assembly.

Radiation protection against solar and galactic cosmic rays.

Our project aligns with these objectives by proposing a **Bio<sup>2</sup> 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

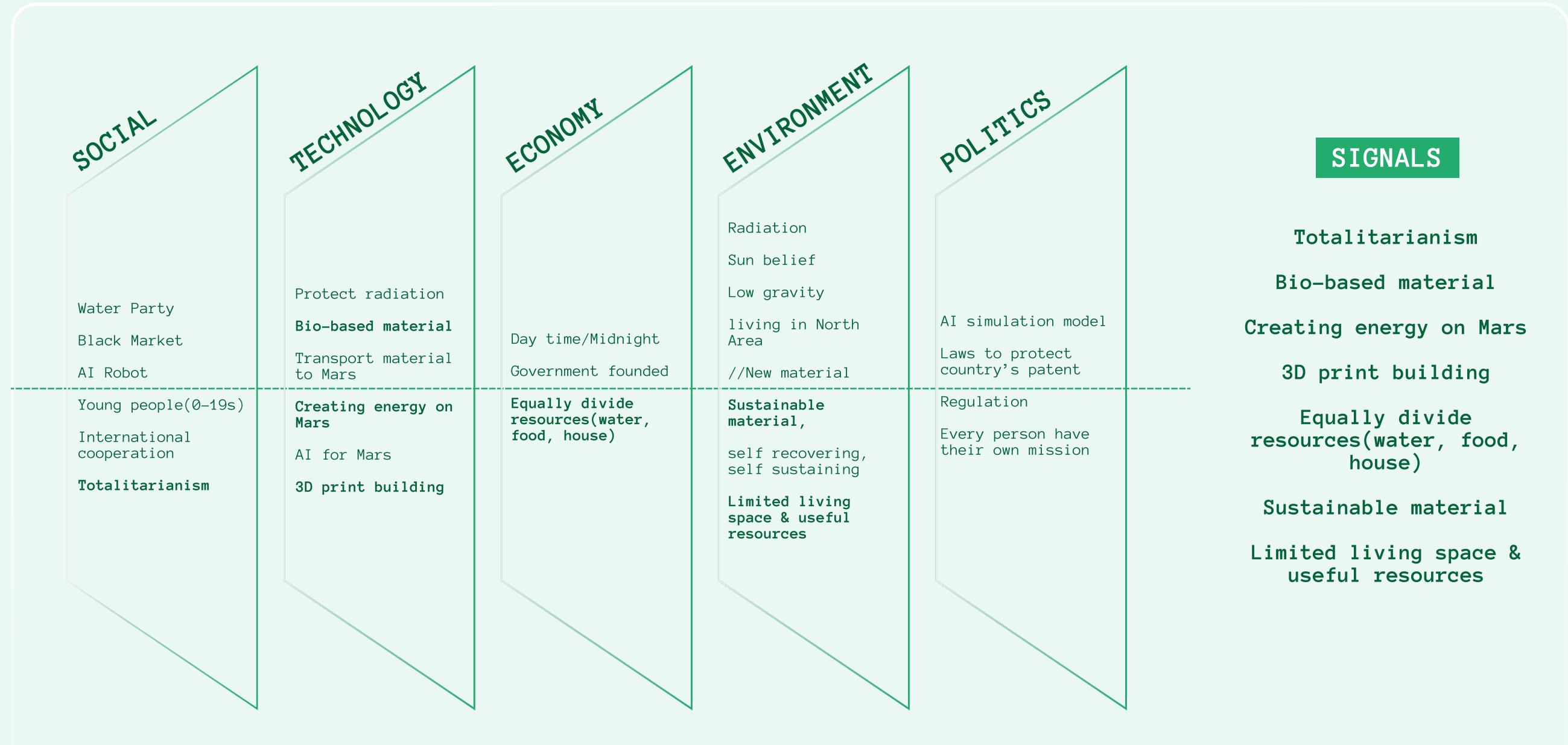
Exploring post-Anthropocene and the **possibilities of life for all species**:

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 >8 G/cm <sup>2</sup> Shielding For <50 MSv/Year; Conventional Polymers Degrade Under Radiation.	Water-Rich Hydrogel (~1.05 × 10 <sup>-3</sup> Kg/Mm <sup>3</sup> ) Absorbs Neutron And Ionizing Radiation; Algae Regenerate Water And Organic Mass
Atmospheric Regulation	CO <sub>2</sub> Buildup And O <sub>2</sub> Shortage In Closed Systems; Mechanical ECLSS Consumes High Energy.	Photosynthetic Algae Convert CO <sub>2</sub> – O <sub>2</sub> , Reducing Mechanical Load; Sensors Monitor Gas Balance In Real Time
Structural Efficiency & Pressure Resistance	Inflatable 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 Reinforcement; Joints Meet NASA F3 2 4 Safety Factor.
Thermal Control	Temperature Swings (150–300 K) Cause Material Strain And Instability.	Hydrogel Provides Thermal Damping: Elastomer Skeleton Convolutes Expansion, Protecan Miner Layers
Modularity & Assembly	Robotic Assembly On Mars Is Complex And Error-Prone	Standardized, Portable Bio2 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



# 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 Purify the air

Bone tissue repair Sustainable construction

Biomonitoring Algae-Laden Hydrogel Could Bring Buildings to Life

- Building

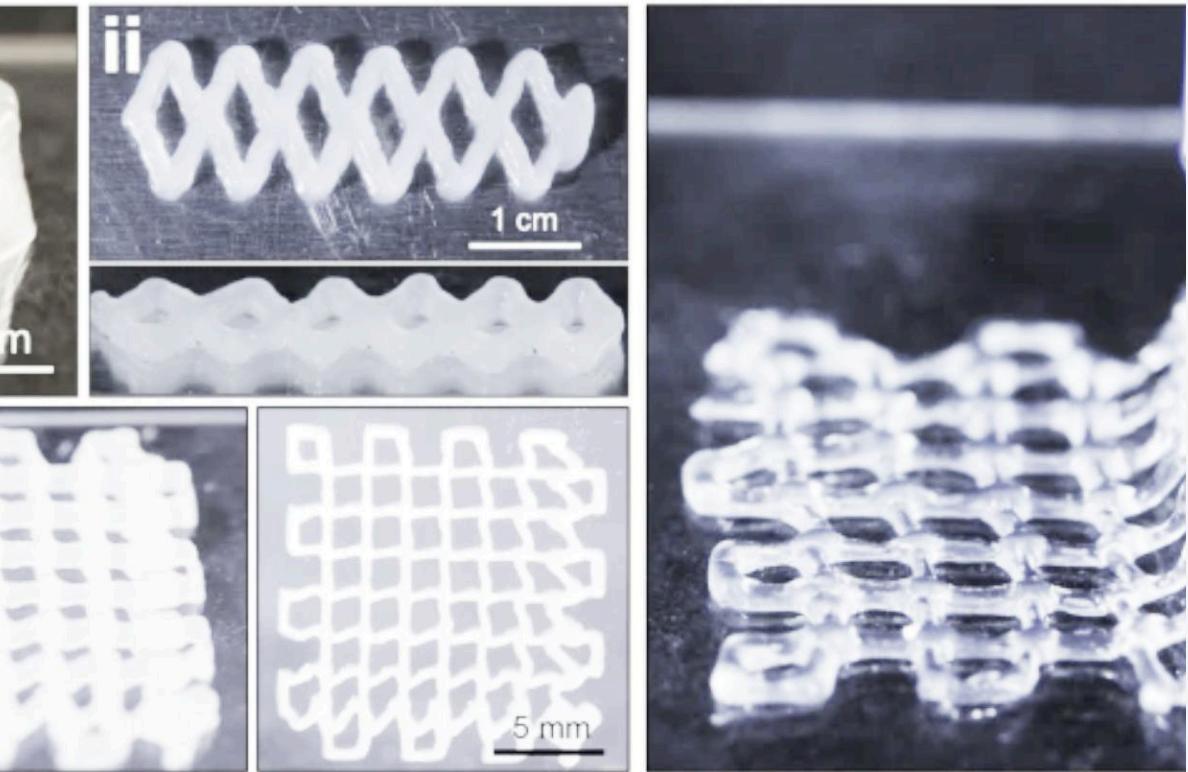
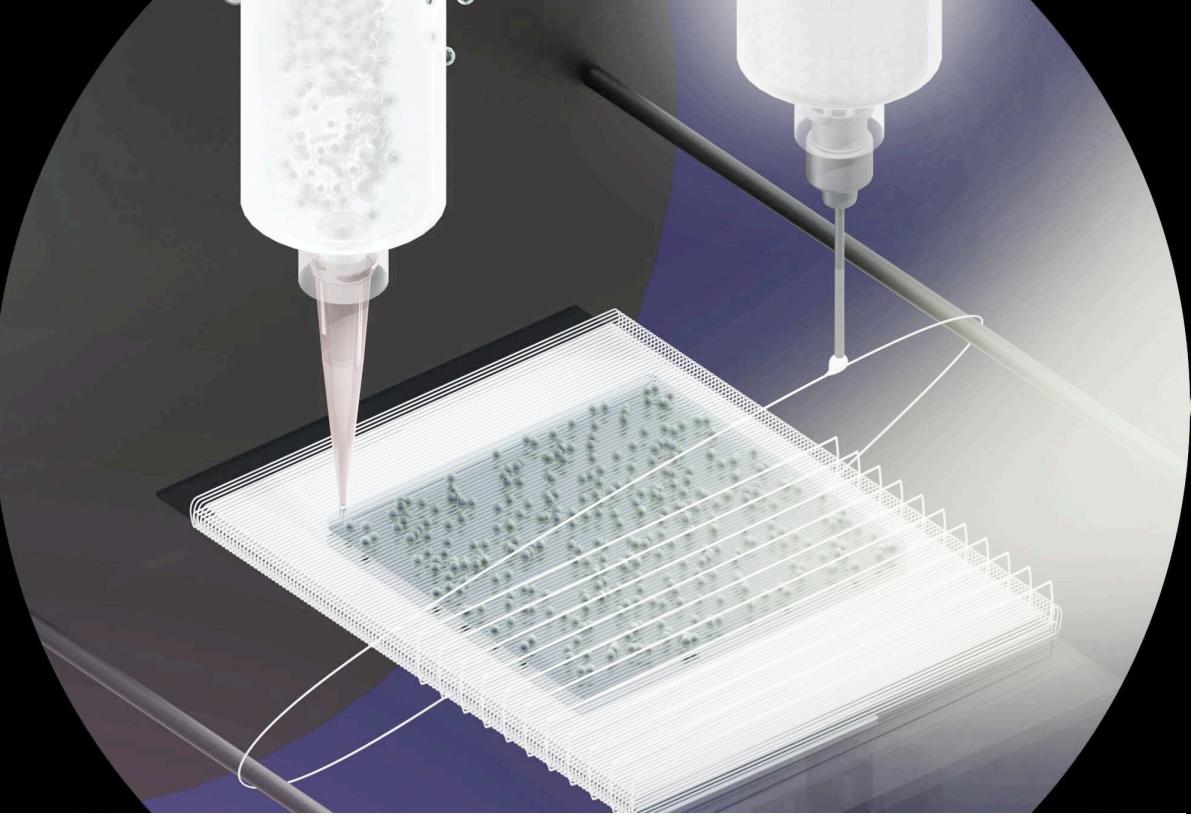


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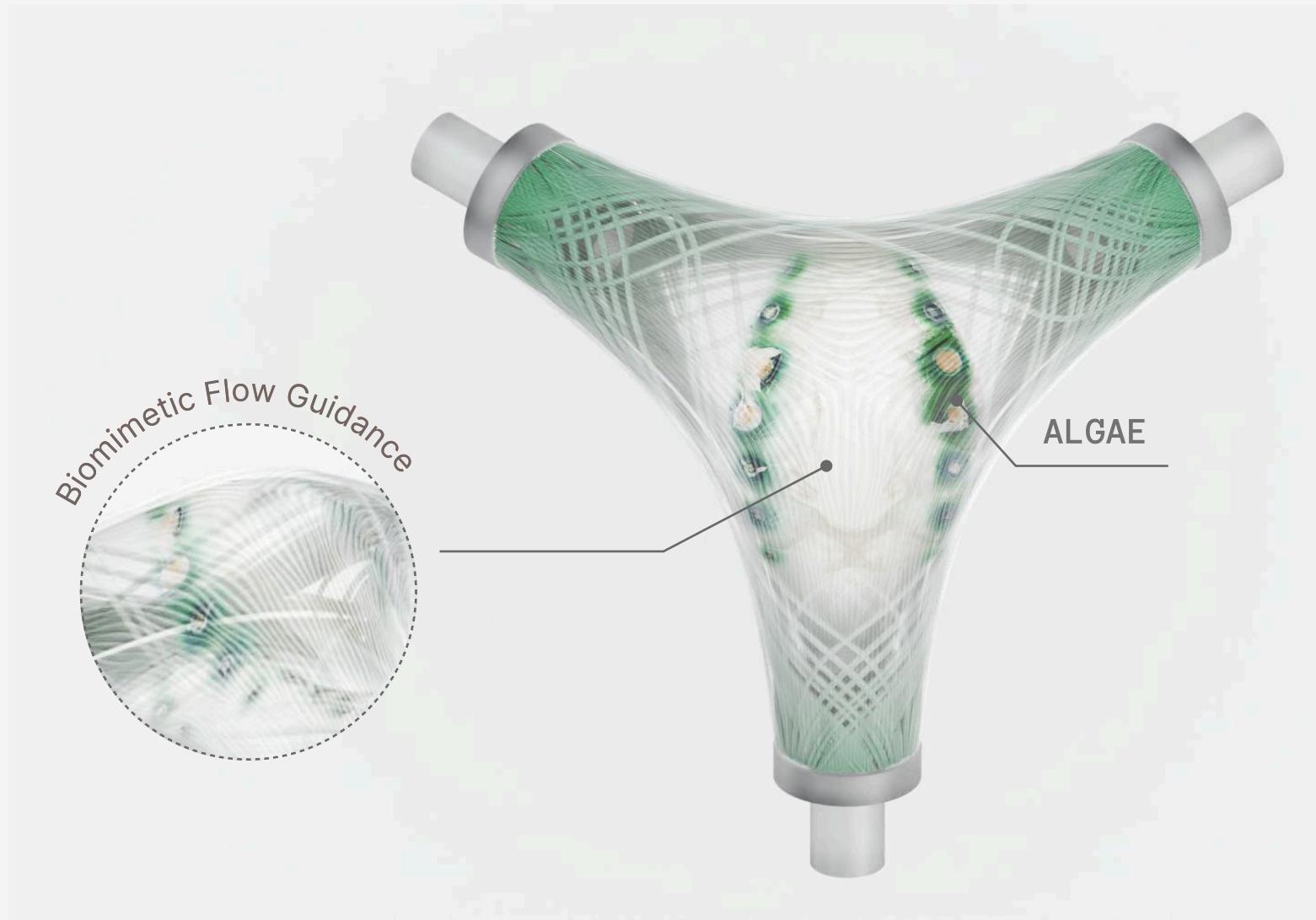
Biopharma. "Top 10 Applications of Hydrogels in Biomedical Field | Biopharma PEG." [www.biochempeg.com](http://www.biochempeg.com), 28 Jan. 2022, [www.biochempeg.com/article/244.html](http://www.biochempeg.com/article/244.html).

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.

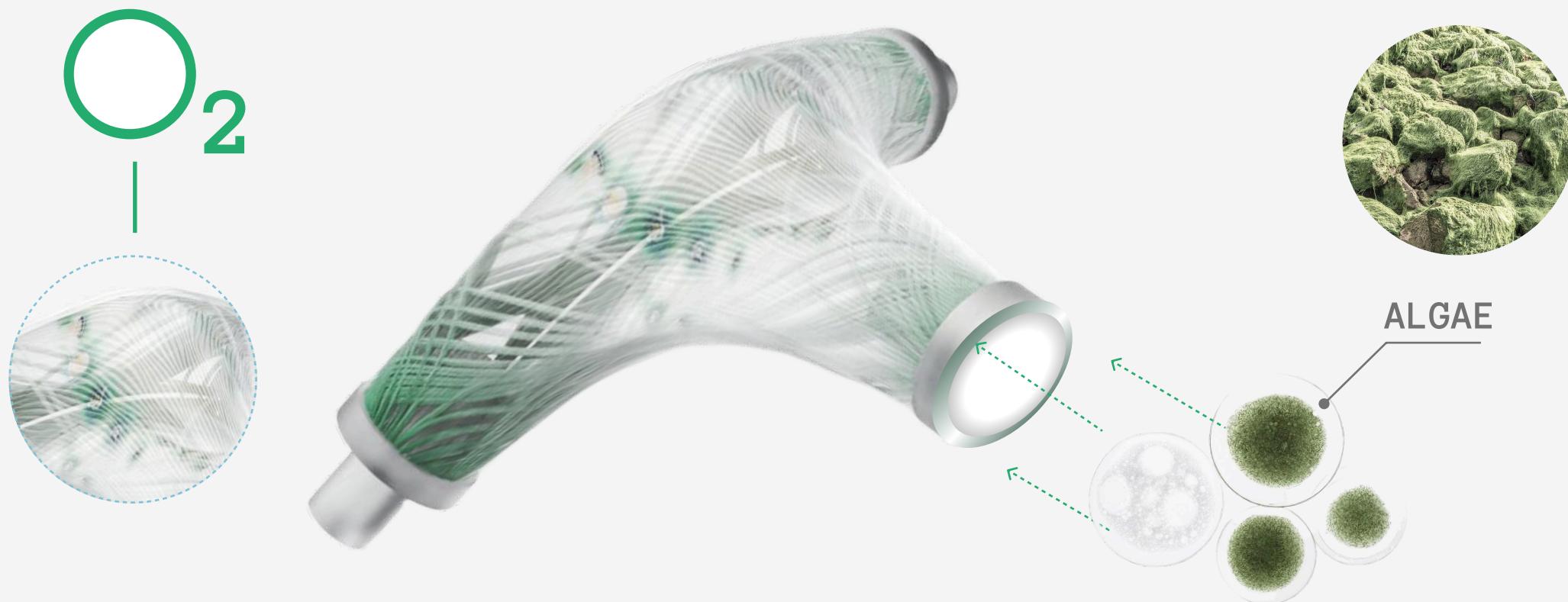
# PRODUCT OVERVIEW



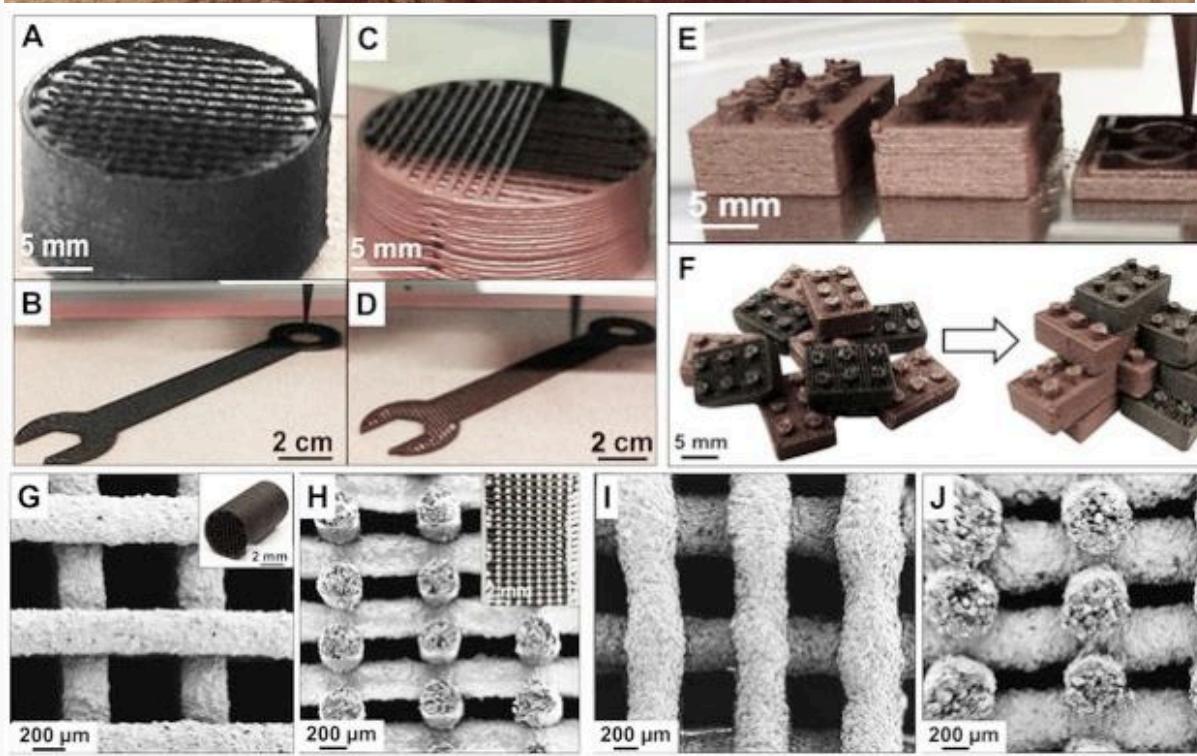
# PRODUCT OVERVIEW



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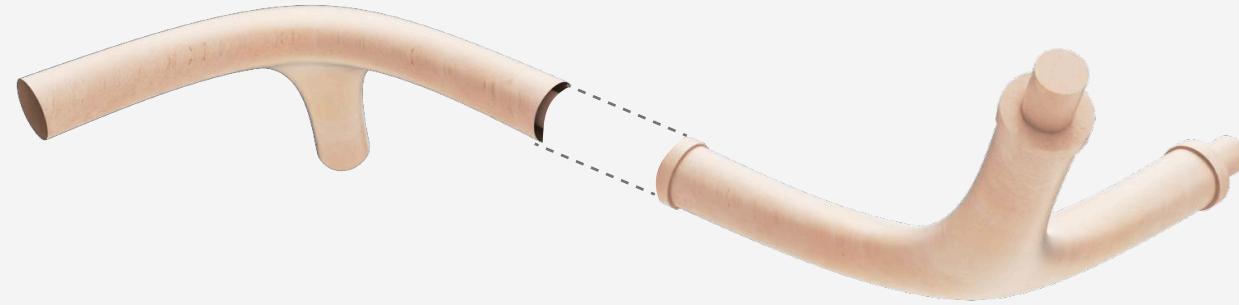


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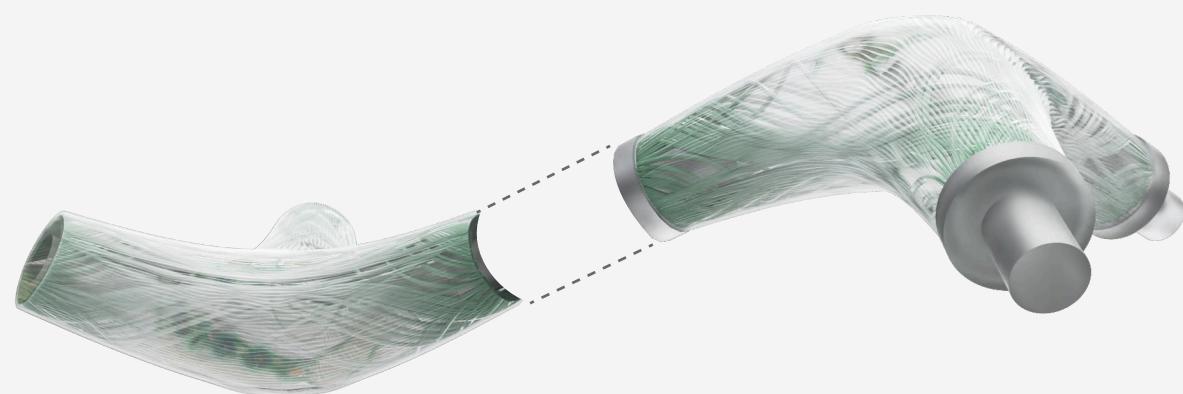
# PRODUCT OVERVIEW

SKELETON



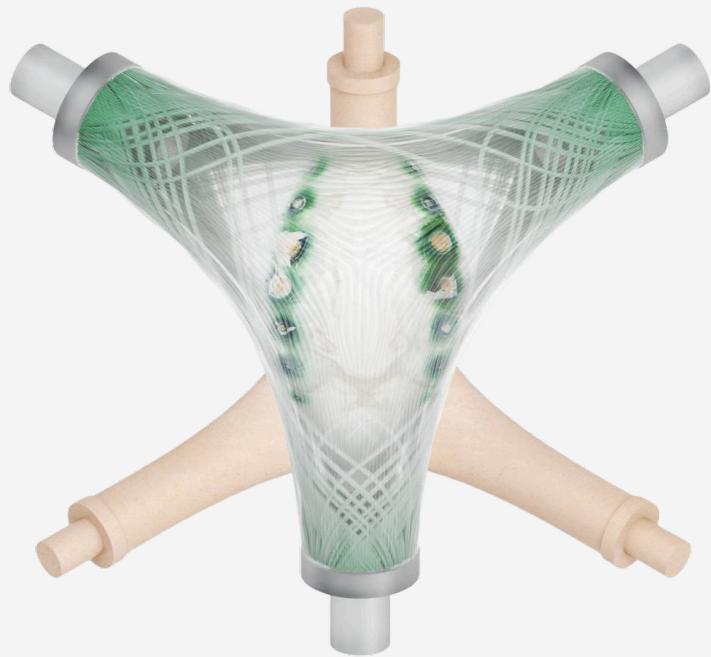
CONNECTING

HYBRID LIVING  
MATERIAL

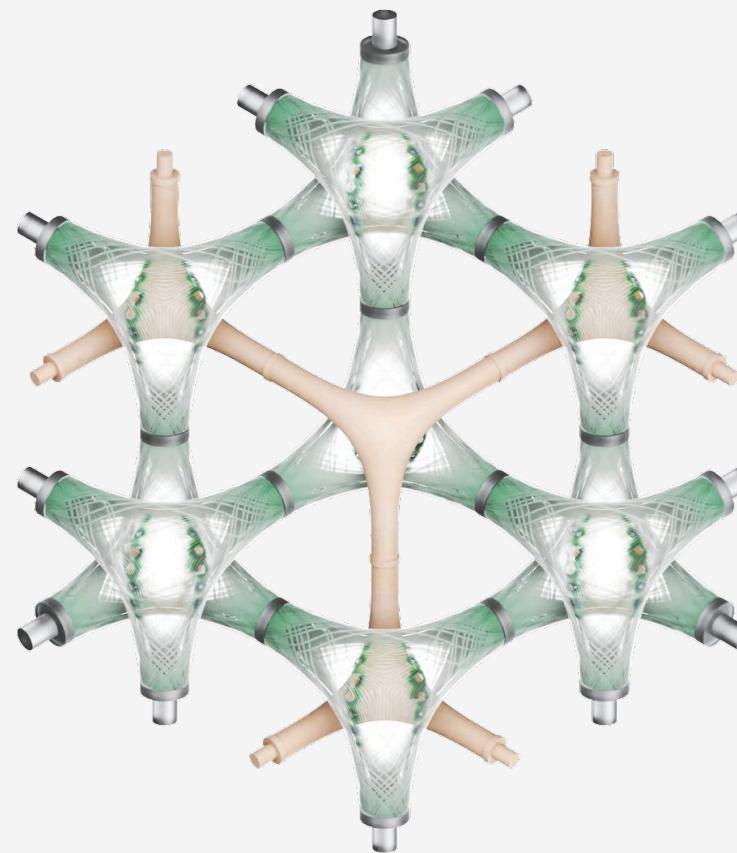


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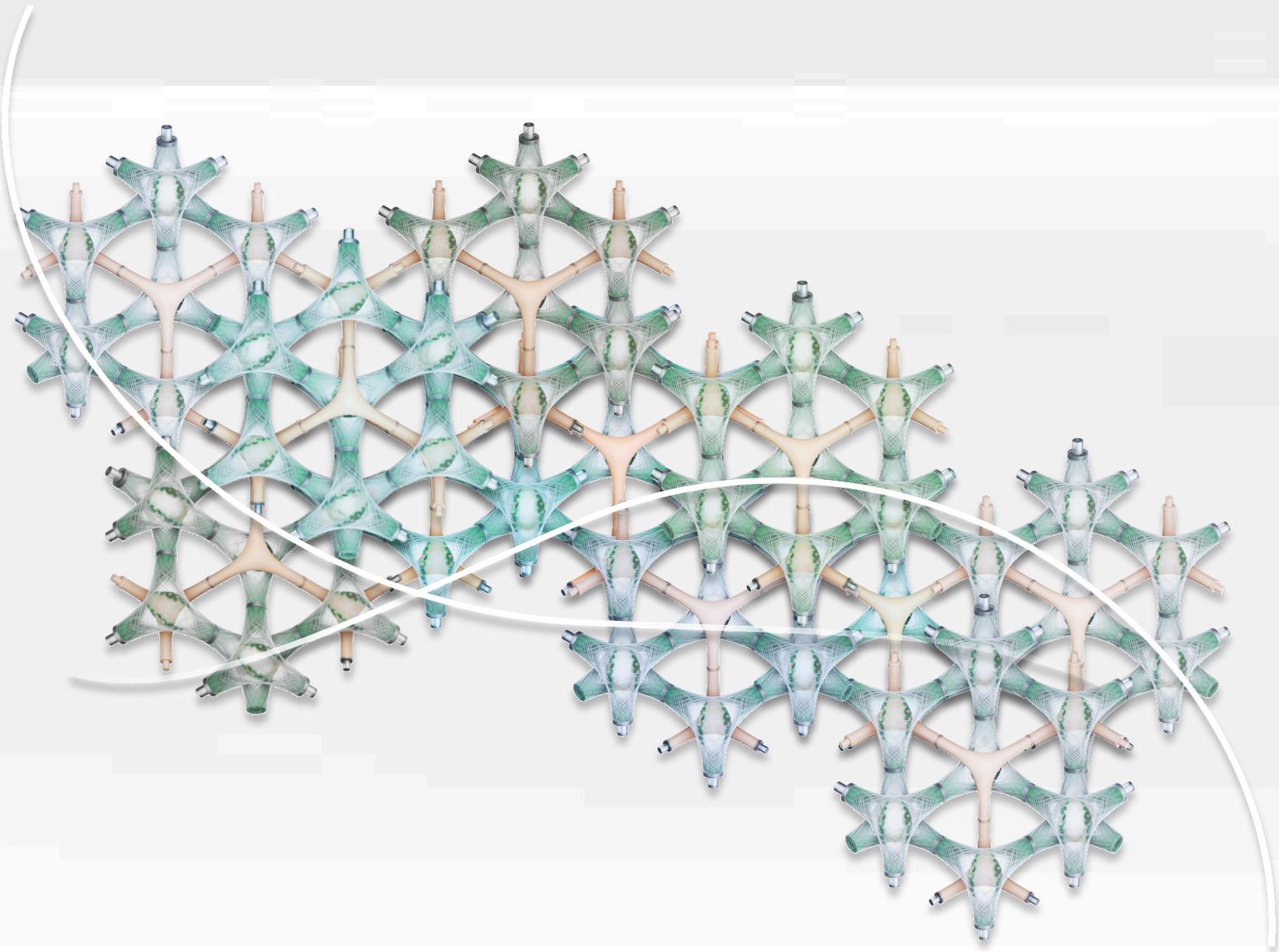
MODULAR



SYSTEM

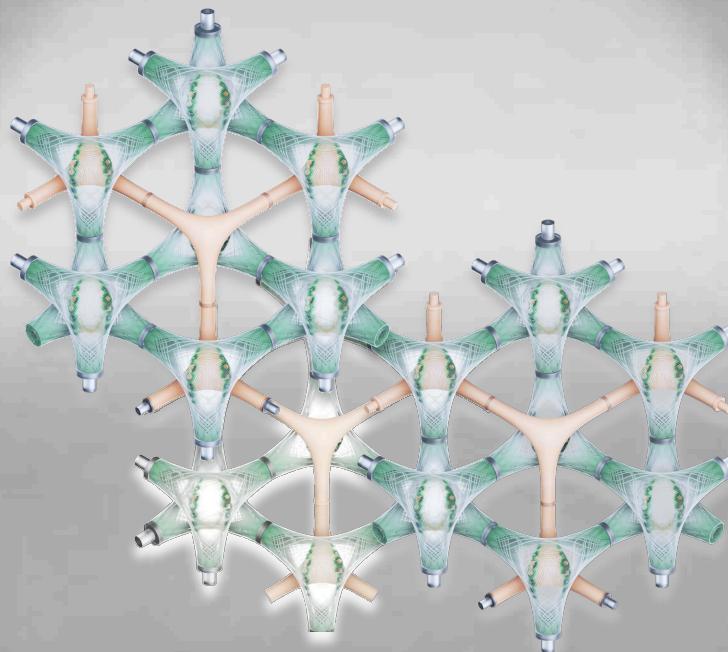


*BIO2*





BIO2



*BIO2*

• NASA Artemis - Moon to Mars Pathway

# Design the Future of Living Beyond Earth

Build modular habitats, simulate BiO2 hydrogel life support, and test mission viability for Moon, Mars, and transit expeditions in real time.

Start Designing

▷ Watch Demo 1

▷ Watch Demo 2

# 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

**Habitat Designer** Untitled Habitat Viability 80%

Duration (days) 30 days

Payload Volume (m<sup>3</sup>) 200

Radiation Level 50%

**MODULE LIBRARY**

- Power Core** 2x2 m  
Power distribution, fuel cells, and battery regulation.  
OXYGEN +0.0 SHIELD L/MIN 18%
- Water Recycling** 2x2 m  
Closed-loop water recovery and filtration racks.  
OXYGEN +0.0 SHIELD L/MIN 16%
- Waste** 2x2 m

2D 3D Save Load Export Share Preview

Day Night

**Atmospheric Cycle**

Oxygen Generation	6.20 L/min	39%
Oxygen Demand	4.26 L/min	
Net Oxygen	1.94 L/min	
CO2 Scrub Reserve	0.8 hrs	

**Power System**

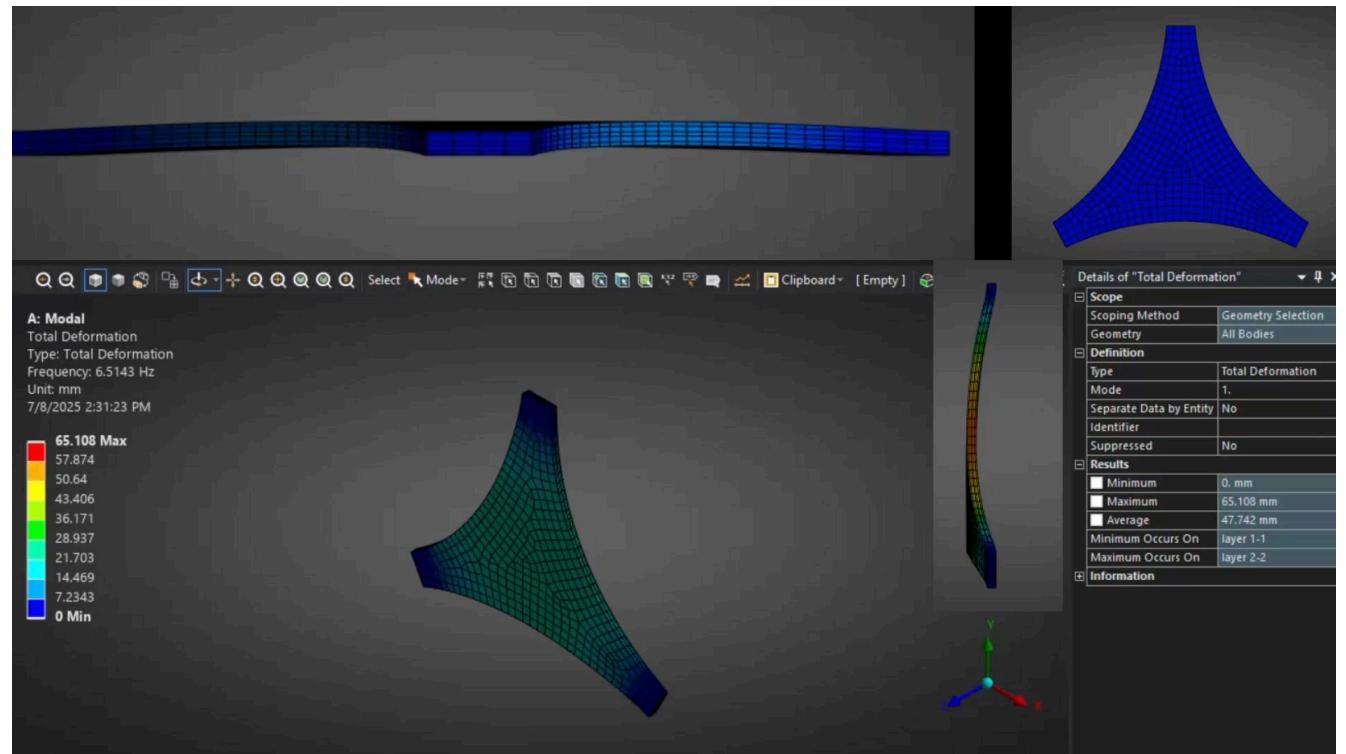
Generation	6.50 kW	0%
Demand	6.70 kW	
Reserve	-0.20 kW	
Thermal Rejection	7.0 kW	

**Water & Hydrogel**

Water Recycling	63.0 L/day	0%
Hydrogel Units	1 active	

# DESIGN / MATERIAL STRUCTURAL ANALYSIS

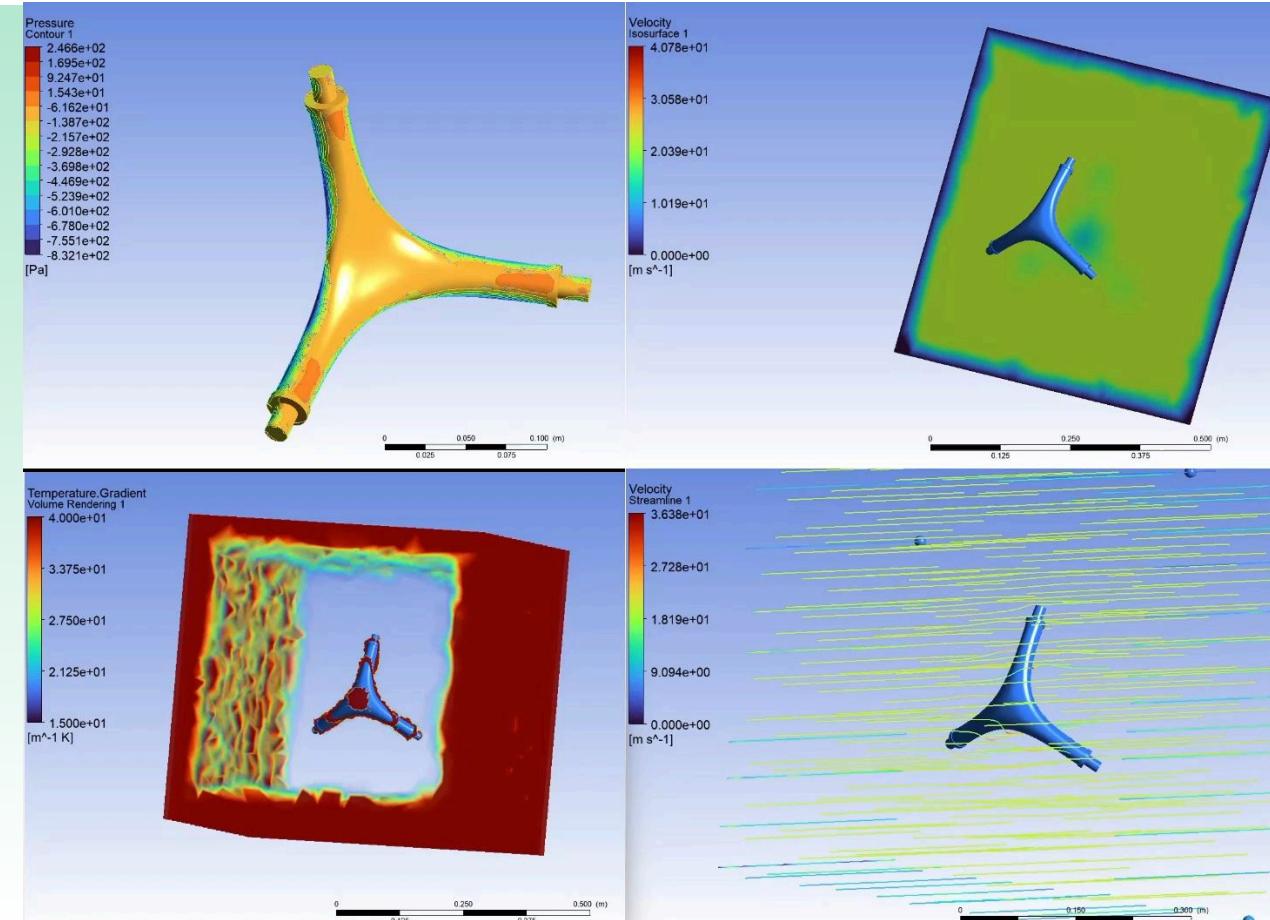
Property	Main Layer	Layer 1-1 / 2-1	Layer 1-2 / 2-2
Density (kg/mm <sup>3</sup> )	$1.05 \times 10^{-6}$	$1.10 \times 10^{-6}$	$1.15 \times 10^{-6}$
Young's Modulus (MPa)	0.02	0.5	5.0
Poisson's Ratio	0.49	0.485	0.48
Bulk Modulus (MPa)	0.333	5.556	41.667
Shear Modulus (MPa)	0.067	0.168	1.689



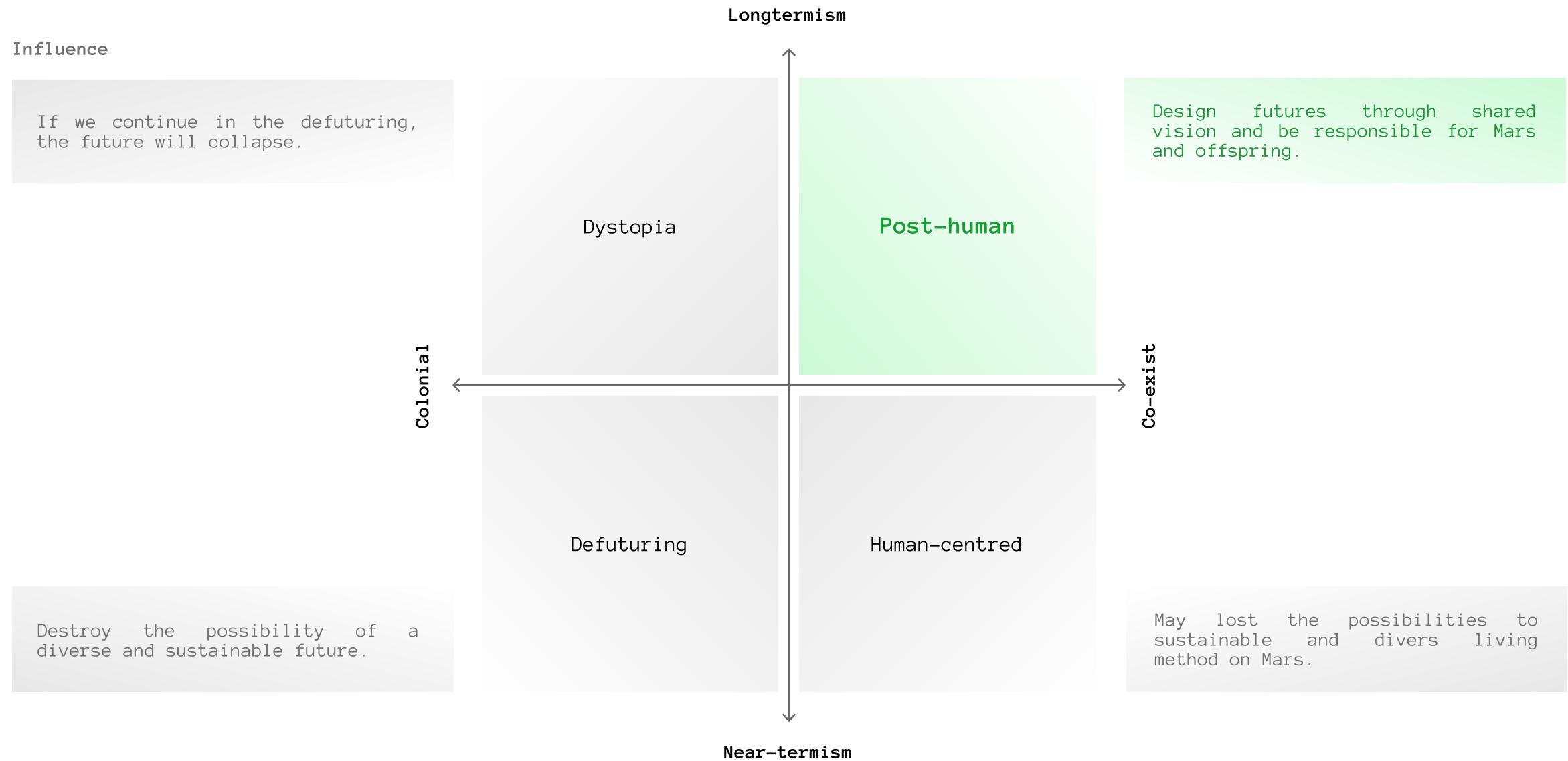
The sandwich plate is designed with increasing stiffness from core to outer layers, ensuring both structural strength and a protected inner environment for bacteria.

# 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



# SCENARIO

Longtermism

Posthuman

Co-exist

Sustainability ↓ Biology ↓ Safety ↓

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

## 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.

## Integrated Algae System

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

## Modular Construction

The Bio<sup>2</sup> system is based on standardized, assembleable 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.

# *BIO2*

*Website Link*



*Github Link*

