Università di Genova | DAD DIPARTIMENTO ARCHITETTURA E DESIGN

Circular design in Action: practices, networks, education and research

Exploring the role of community and education in driving action-oriented research and practical innovation

edited by:
Federica Delprino, Silvia Pericu
University of Genova,
Department Architecture and Design (DAD)

Co-funded by the European Union

CiD circular design

Proceedings of the Conference „Circular design in action: practices, networks, education and research - Exploring the role of community and education in driving action-oriented research and practical innovation".
Conference in Genova, 22-23 May 2025
„Circular Design Education" conference
from **CiD Erasmus+ Project** - www.cid-innovationalliance.eu

conference organized by
UniGe DAD CiD team - Department of Architecture and Design
- University of Genova: Silvia Pericu, Federica Delprino, Niccolò Casiddu, Luisa Chimenz, Nicola Canessa, Giorgia Tucci, Manuel Gausa, Chiara Olivastri, Claudia Porfirione
with: Stella Femke Rigo, Chiara Garofalo, Lara Ippolito, Omar Tonella

scientific committee
Helen Arme, Pilar Bolumburu, Fiona Demeur, Larissa de Rosso, Martynas Germanavičius, Marite Guevara, Lizeth Lopez, Concetta Montagnese, Alessandro Pernice, Nele Plutus, Jörg Schröder, Charlene Smith, Federica Tenaglia, Jackie Williams

The papers in these proceedings were selected through an open call and underwent double-blind peer review.

edited by:
Federica Delprino, Silvia Pericu
University of Genova,
Department Architecture and Design (DAD)

concept layout:
Federica Delprino, Anna Pape

typesetting:
Federica Delprino, Francesca Costanzo

published by:
Regionales Bauen und Siedlungsplanung, Leibniz Universität Hannover
Herrenhäuser Str. 8, D-30419 Hannover
ISBN 978-3-946296-55-3
www.staedtebau.uni-hannover.de/en/territorial-design-and-urban-planning/

Co-funded by the European Union, Erasmus+ Innovation Alliance, Grant 101111686.
Published in the framework of CiD Circular Design Innovation Alliance.

The Innovation Alliance Circular Design (CiD) offers a radically new model on how to link design to circularity and urban transformation. The Alliance aims to establish benchmarks for rethinking design in a circular economy, shifting urban design, architecture, product and service design towards carbon-neutral cities, and enhancing bio-based innovation for building.

Blueprints for green, resilience, and digital skills are to support the change towards sustainable, inclusive, affordable cities. They boost the turn to a circular construction and design econ my driven by culture and creativity.

CiD operates on three levels: the co-creation of knowledge on circular design, the set-up of an innovation ecosystem for circular design, and educational innovation in academia, green entrepreneurship, and continuous learning and upskilling.

The CiD Innovation Ecosystem brings together relevant actors from academia, research, business incubators, continuous education, civil society organisations, and enterprises. The evolution of the Alliance's results, their dissemination and sustainability beyond the project is supported through the involvement of Europe-wide organisations in architectural practice, society, and culture.

Local and Europe-wide observatories set up within CiD aim at including relevant stakeholders to connect the education and research environments with the surrounding socio/economic environment. The Observatories will contribute to the framework of challenges for the co-creation and flow of knowledge and to novel models for challenge-based education.

Circular design in Action: practices, networks, education and research

Exploring the role of community and education in driving action-oriented research and practical innovation

The Circular Design in Action: Practices and Research conference - organized by Department Architecture and Design of University of Genova - invites scholars, researchers, designers, and practitioners to share their insights and innovative approaches in circular design. This event is part of the CiD Project – Circular Design for Bio-based Innovation towards Climate-Neutral Cities, an initiative fostering sustainable solutions in architecture, product design, and urban transformation.

In an era of pressing environmental challenges, design plays a fundamental role in shaping a sustainable future. The conference will explore circular economy principles, bio-based materials, and innovative design methodologies that drive the transition toward carbon-neutral cities. Participants will have the opportunity to showcase research, methodologies, and practical applications that redefine how materials, products, and built environments are designed, produced, and regenerated, within two tracks:

+ Track 1: Design for change
+ Track 2: Circular Cities

table of content

5.6 Designing with the living

The emerging paradigm of biofabrication

Marco Marseglia, Francesco Cantini, University of Florence
Department of Architecture

KEYWORDS | #Biotinkering #Biodesign #Biofabrication #Transdisciplinarity #Material Design

Abstract

The paper examines biofabrication as an emerging paradigm in material design, exploring transdisciplinary approaches, innovative educational practices, and concrete applications at the intersection of design and biosciences. The contribution presents teaching and research experiences that promote alternative and sustainable production models. It illustrates research activities carried out within the Biodesign Research Unit and the design of a biodesign laboratory. These experiences aim to bridge the methodological and infrastructural gap that currently separates design from science.
In this way, biofabrication emerges as a strategic field for addressing the ecological transition and redefining the relationship between design, nature, and materials.

1. Ecology of Matter: Designing Within the Material Transition

The ongoing environmental crisis demands an urgent reflection on current models of design, production, and consumption. According to a recent study conducted by the Weizmann Institute of Science, humanity has surpassed a critical threshold in which the global mass of artificial (anthropogenic) materials has exceeded that of the Earth's biomass (Elhacham et al., 2020). There is now more plastic, concrete, and asphalt on the planet than animals and plants combined. This alarming signal is symptomatic of a systemic transformation—what can be defined as a "material transition"—which calls for a radical rethinking of how design interfaces with materials, how they are conceived, fabricated, manufactured, and used. The phenomenon of material transition can be described as a hyperobject, a key concept introduced by Timothy Morton (2013) that helps us understand complex contemporary phenomena such as climate change and the ecological crisis. It suggests that these are not external occurrences but omnipresent entities, distributed across space and time, entities that challenge the very definition of a "design problem."

Within this framework, the designer's responsibility expands—beyond decisions concerning the form or function of products—to encompass the ways in which the materials themselves are conceived and produced.
The generation of material designers (Karana et al., 2015), together with the DIY-Materials movement (Rognoli et al., 2015), integrates material development into the design process. The practice of self-producing materials, following the logic of Material Tinkering (Parisi et al., 2017), represents a turning point in design, triggering a rethinking of the discipline itself and its relationship with materials.

2. Transdisciplinary Approaches to Material Design

Over the past two decades, material design has undergone a profound transformation through the adoption of multidisciplinary approaches that combine design, biology, chemistry (Langella, 2019), neuroscience (Biondi et al., 2009), and materials science. The contemporary designer no longer limits themselves to selecting existing materials but actively participates in their definition and production (Trebbi, 2024), collaborating with biologists and material scientists to design more efficient, sustainable, or functionally advanced materials. In particular, biodesign (Myers, 2012) has become a well-established area of investigation within academic research and, in recent years, has been gaining increasing relevance in the job market. Designing through biofabrication—thus with living matter—implies adopting a transdisciplinary approach that overcomes the barriers between design and scientific knowledge, integrating expertise from both domains. Consequently, a radical rethinking of design education is required, as designers must internalize new methods and acquire both theoretical and practical tools to operate effectively in contexts where biology and design converge (Lucibello & Montalti, 2019).

This transdisciplinary approach is clearly exemplified in the projects of research institutes such as the MIT Media Lab or the current Oxman Studio, where biologists and designers co-develop biological materials, as seen in the Aguahoja and Silk Pavilion projects; or in Suzanne Lee's Biofabricate, a global platform promoting biomaterial innovation through collaboration between design and biotechnology. Pioneers such as Neri Oxman and Suzanne Lee have inaugurated a flourishing generation of innovators: among them, Ginkgo Bioworks and Modern Meadow are biotech companies collaborating with designers to produce biofabricated synthetic materials, such as cruelty-free leather or cell-cultivated textiles.

Officina Corpuscoli, founded by Maurizio Montalti, is a pioneering studio in the field of biodesign, focused on the biofabrication of materials and products based on fungal mycelium.
From Officina Corpuscoli's research emerged Mogu, an Italian company that produces mycelium-based biofabricated materials for architecture and interior design applications. Mogu transforms agro-industrial residues into fully compostable acoustic panels and flooring, demonstrating the industrial scalability of biomaterials. A few years after Mogu's foundation, SQIM was established—a technology holding company that includes Mogu—and launched Ephea, a brand developing alternative leather materials using mycelium to create innovative textiles.
A notable example is its collaboration with Balenciaga, which introduced a coat made from Ephea materials in the Winter 22 collection.
The Officina Corpuscoli–Mogu–Ephea–SQIM case study represents an exemplary instance of design-driven innovation in the biofabrication of materials, capable of scaling a technology's readiness level from "TRL2 – Basic technologies research" to "TRL10 – System Test, Launch & Operations."
Equally exemplary is the approach of Spiber, a Japanese startup producing materials through microbial fermentation of agricultural feedstocks. This biofabricated material is used in the fashion and automotive industries. In parallel, AMSilk develops biopolymers inspired by spider silk through industrial biotechnologies. Its patented material, Biosteel, combines high environmental performance with strength and lightness, and has been used in products such as Adidas' Futurecraft Biofabric shoes. The U.S.-based Bolt Threads develops sustainable materials such as Mylo (mycelium leather), B-silk, and Micro-silk, inspired by spider silk. The company collaborates with Stella McCartney and Adidas, and in 2017 launched the Boltspun tie made from Micro-silk. The Dutch studio Klarenbeek & Dros has created 3D-printable biopolymers derived from algae, opening new opportunities for rapid prototyping.
These transdisciplinary approaches demonstrate that material design is increasingly becoming a hybrid practice, where sensory and perceptual criteria of materials (Carullo & Pagliarulo, 2018), typical of a "tinkering" approach, merge with biotechnological processes and scientific knowledge, revealing a knowledge gap to be bridged within the design disciplines.

3. Biofabrication as a promising design strategy

Designers are increasingly facing the need to master wetware tools—those traditionally belonging to the biosciences or that hybridize the biological and the digital (Cantini, 2024). Wetware refers to living biological systems and differs from software (the immaterial component of a system) and hardware (the physical component). Unlike the latter, wetware processes information through biochemical and

neural mechanisms rather than electronic ones, requiring designers to develop greater awareness of biosciences.
In this context, the hybridization of design and biology for the production of products and materials through the metabolic activity of various forms of life represents two significant trends.
In light of these transformations in the discipline, the role of the designer within the biological laboratory is increasingly established (Pollini, 2024)—a space where many of the previously mentioned methods are implemented with the aid of precise instrumentation.

One of the most promising wetware tools in the hands of designers is biofabrication (Camere & Karana, 2018). Borrowed from regenerative medicine and tissue engineering, the term refers to the fabrication of biologically functional constructs with organized structures made from cells, microtissues, bioactive molecules, and/or biomaterials through top-down (bioprinting) or bottom-up (bioassembly) processes (Moroni et al., 2018). Biofabrication processes have led biodesigners to develop projects involving living organisms such as algae, fungi, bacteria, or various types of living cells.
Although this may seem novel, humanity has long relied on microorganisms for production. For thousands of years, yeasts, bacteria, and molds have been used to brew beer, ferment wine, leaven bread, and age cheese.
Today, bacteria cultivated in vats are induced to produce food additives, antibiotics, industrial chemicals, vitamins, and more (Benyus, 1997).

These processes are exceptionally dynamic, and the relationship established with living elements must be collaborative. Microorganisms cannot be "forced" to act but must be "invited" and "coordinated" as collaborators, so they can apply their intelligence within the process through continuous exchange with the designer (Lucibello & Montalti, 2019). Biofabrication applied to design is a relatively new interdisciplinary research field that combines principles of biology, engineering, design, and materials science to produce biomaterials (such as mycocomposites, bacterial cellulose, etc.) or products in which biological processes are integrated into their function (Cruz & Parker, 2022).

This innovative approach exploits the intrinsic ability of cells and living organisms to grow, reproduce, and produce specific substances.
It is widely used in tissue engineering (to create complex three-dimensional structures such as artificial organs, synthetic skin, cartilage, or bone) and in the production of lab-grown foods (thus reducing dependence on the meat industry and high-impact food sources).
Designers using biofabrication tools can, through collaboration with scientists and biotechnology specialists, design processes for the engineering of microorganisms—that is, for the genetic manipulation of bacteria, yeasts, and fungi to achieve specific characteristics or perform particular functions.
Biofabrication techniques can lead designers, through in vitro (laboratory) and in vivo (outside the laboratory) cultivation processes, to the development of Living Building Materials (LBM) (Alemu et al., 2022)—"living" materials that use microorganisms to produce construction components with mechanical and biological properties (Qiu et al., 2021)—or Engineered Living Materials (ELM), materials endowed with life-like capabilities such as self-growth, self-healing, environmental responsiveness, and evolvability (Wang et al., 2022).

A growing number of studies are emerging in this area, and such biotechnologies are becoming increasingly accessible to designers (Crawford, 2023). Biofabrication techniques are employed in construction, furniture, design, architecture, packaging (Alemu et al., 2022), and pigments (Ahmad et al., 2012; Kothari et al., 2016; Narsing Rao et al., 2017; Pantanella et al., 2007). Sometimes, biofabrication processes hybridize with those of digital fabrication, giving rise to hybrid tools of bio-computational design (Cruz & Beckett, 2016), biodigital fabrication, and biodigital manufacturing—as exemplified by the additive manufacturing research conducted by Blast Studio or Biomatters.
Designers using biofabrication tools must follow strict growth protocols and, therefore, make use of tools such as the biodesign agenda (developed within the workshop Material Beyond Materials III), an instrument that facilitates scientific inquiry and design synthesis of biofabricated materials. Biofabrication thus

holds the potential to revolutionize multiple design sectors, including packaging, construction, fashion, and furniture. However, ethical and scientific challenges associated with the use and manipulation of living organisms for manufacturing purposes must not be overlooked.

The debate on genetic editing remains particularly intense and divides the scientific community. Biofabrication emerges as one of the most promising tools of biodesign, as it enables the production of materials and objects from living cells, microorganisms, and biological processes (Moroni et al., 2018), thereby offering a radically more sustainable alternative to conventional production methods. In biofabrication, the designer no longer works solely with raw matter but with its capacity for growth and transformation, introducing the variable of "life" into the design process.
This innovation is grounded in a new relationship between form and matter, in which design must include the definition of "environmental parameters" (light, temperature, humidity, nutrients) to stimulate specific biological behaviors and material reactions (Cantini, 2024). This entails a radical revision of design tools, which must now integrate growth models, biological algorithms, laboratory instruments, and wetware such as fermenters, bioreactors, and biological hoods.

This practice lies at the intersection between science and design, requiring new "bio-literate" professional figures capable of interfacing with complex new tools. The adoption of a shared language among disciplines (Langella, 2019) is an essential condition for design practices implementing biotechnological processes.

Nonetheless, a significant gap remains between theoretical potential and actual applicability, limited by technical barriers (such as the complexity of developing large-scale production systems) and regulatory constraints (related to the ethics of synthetic biology and genetic editing).

4. Biofabrication Practices in research and teaching

The Design for Sustainability Laboratory, through the network of the Biodesign Research Unit[1] at the University of Florence, has in recent years developed research projects and educational pathways aimed at translating biofabrication from a theoretical concept into concrete design experiences that demonstrate the transformative potential of this practice.
The workshop Material Beyond Materials III: Biodesign Edition (Marseglia et al., 2025), organized in collaboration with the company Circular Farm, Funghi Espresso, represented a

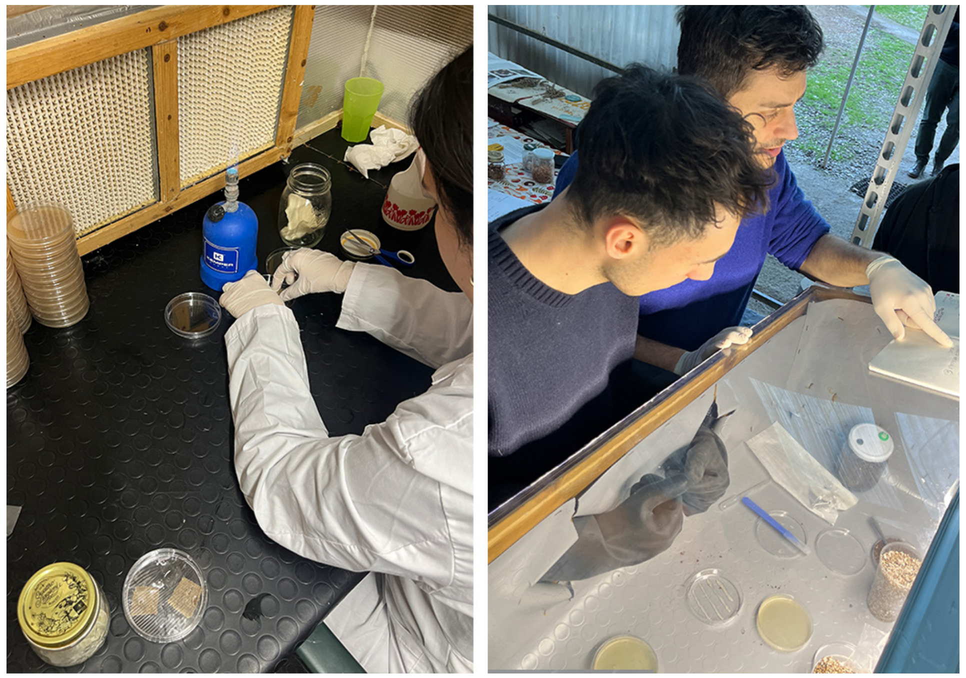

Fig. 1 - Material Beyond Materials III Workshop: Transdisciplinary collaboration between designers and biologists.

transdisciplinary educational experience aimed at integrating biological methods and tools into design education. Through a 3-ECTS course, design students were guided by a multidisciplinary team of instructors in a series of experiments with biofabricated materials based on the mycelium of the fungus Pleurotus ostreatus within a BSL-01 laboratory (Fig. 1). This initiative sought to train a new generation of biodesigners capable of addressing the challenges of the material transition (Elhacham et al., 2020) through a systemic and transdisciplinary approach, where nature, understood as a living and active agency, is considered a co-designer in the creative process.

The workshop was structured as an experimental co-design action focused on the exploration of biofabrication processes by designers. Organized into six main phases, it implemented the TMBT (Transdisciplinary Material BioTinkering) method—a pedagogical and design approach articulated in six steps that guide future biodesigners in the conception and realization of biofabricated materials, fostering dialogue between design and biology. The workshop led a group of twenty students in designing a biofabricated mycocomposite material (Fig. 2) and represented an experimental and unprecedented educational experience (and therefore still subject to refinement) that introduced the themes of biofabrication and synthetic biology into design curricula.
The project INERTIAL – INnovative matErial fRom TraditIonAL resource[2], developed at the University of Florence between 2021 and 2023, focuses on recovering by-products from the Tuscan stone industry (Carrara marble, Rapolano travertine, Firenzuola sandstone, etc.) to produce innovative biofabricated materials for biobuildings (Fig. 3) through the metabolic principle of biomineralization by photosynthetic microorganisms (Fig. 4) (Microbial Induced Calcite Precipitation – MICP) (Reali et al., 2022).

The project, awarded in the ADI Index 2025 selection in the “Research for Business” category, implemented a transdisciplinary methodology within Material Design, involving collaboration among designers, biologists, and experts in agricultural microbiology (Marseglia et al., 2025).

The technology developed during the two-year INERTIAL project, currently under patent application, led to the creation of the start-up Bioma Design Lab[3], a university spin-off focused on the biofabrication and commercialization of materials developed within the project. Bioma positions itself as a material company capable of supporting businesses in the decarbonization process within the bio-construction sector. Winner of the 2023 edition of Impresa Campus UNIFI—a program supporting the creation of innovative enterprises by young researchers—the startup aims to transform by-products from the stone supply chain into products and semi-finished materials applicable in bio-construction and interior design. Both the bio-construction and marble-stone sectors represent strategic industries for Italy, giving the project the potential to generate positive and tangible impacts within its reference context.

Bioma Design Lab thus acts as a research and development platform for biofabricated materials within the biodesign paradigm. Its founding idea is to use quarry and sawing waste to biofabricate construction materials through microbial biomineralization processes.
The resulting artifacts offer a sustainable alternative to conventional petrochemical-based building materials while reducing the environmental and economic costs associated with marble slurry disposal. Bioma aspires to become a virtuous example of design-driven technology transfer in the field of biofabrication.
AERIAL – strAtEgie di biofabbRIcAzione per il recupero di sottoprodotti Lapidei[4] represents the follow-up to the INERTIAL project and is aimed at implementing a pilot plant and producing the first prototypes. The project is funded by the Tuscany Region (R&S POR FESR 2021–2027 call) and directly involves all stakeholders in the design process, particularly a company in the marble/stone sector, Vetrugno Marmi S.a.s., which alone produces 22 tons of marble slurry per day, and Bioma Design Lab, responsible for transforming this waste into products useful for bio-construction.

The project directly impacts the reference socio-ecological system at multiple levels: upstream, it involves all companies in the stone district; downstream, it benefits entities engaged in the design and implementation of bio-construction, providing them with new circular and low-impact products and semi-finished materials created through biofabrication processes.
AERIAL will have a positive impact on the Apuan–Versilia area, as the pilot plant will be located in Montignoso, at the former Fornace quarry. The underlying idea is to regenerate a former quarry converted into a landfill, transforming it into a site of renewal aligned with the principles of regenerative and restorative design (Wahl, 2022; Lyle, 1996; Reed, 2007; Antonelli & Tannir, 2019), creating social and environmental value, as well as economic value, for the region (Armiero, 2021).

5. Disciplinary and Infrastructural Gap

Despite numerous experiments, significant disciplinary gaps persist: many designers' explorations of biofabrication are conducted in a “monodisciplinary” manner, that is, without the involvement of expert scientists. This often leads designers to make serious mistakes and develop biases. The gap concerns not only knowledge but also tools; even when working groups are heterogeneously composed of designers and biologists, universities, research centers, and companies often lack adequately equipped spaces to carry out such experiments.
The absence of suitable laboratory facilities greatly limits the ability of both students and faculty researchers to explore this field.

Biological safety cabinets, incubators, and bioreactors are still unavailable in most design teaching and research spaces, making it difficult to move from material concept development to sample production.These challenges led to the creation of the Biodesign Research Unit (UDR Biodesign) at the Department of Architecture of the University of Florence, established to bridge the “disciplinary gap” that characterizes the current landscape of biodesign within the university. The Biodesign Research Unit (Fig. 5) brings together several laboratories from different departments of the University of Florence, in-

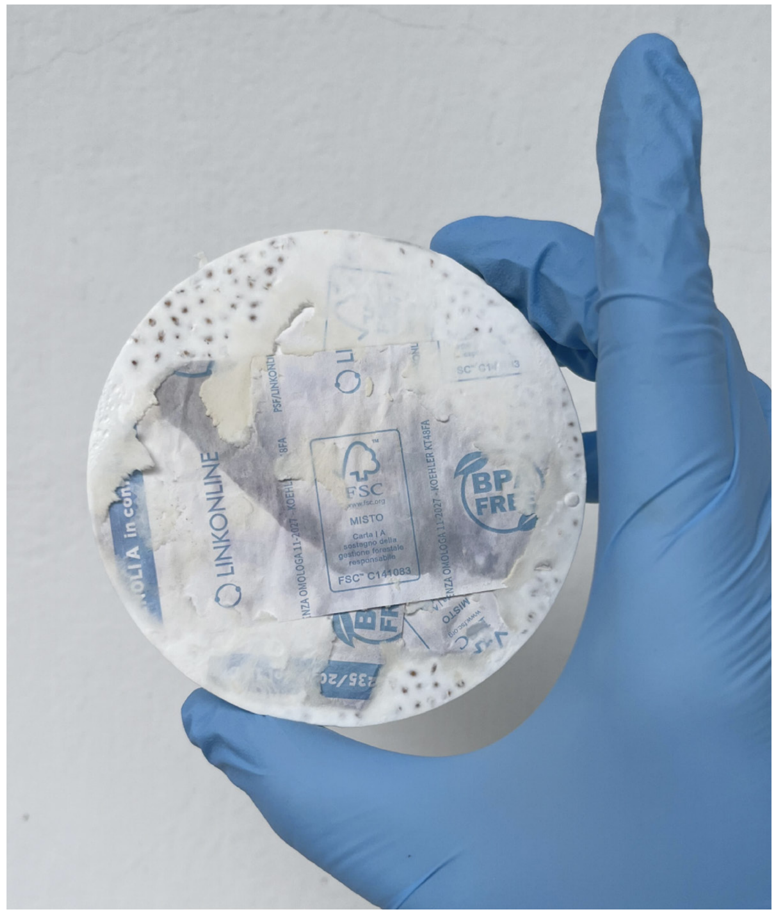

Fig. 2 - A sample of micocomposite material on a receipt substrate developed by students as part of the Material Beyond Materials III workshop (Credits: Rachele Moriconi).

Fig. 3 - INERTIAL project: A sample of biomineralized material produced for mechanical bending and compression tests. Standard dimensions: 160x40x40 mm (Photo credits: Cristian Betti).

cluding the Design for Sustainability Laboratory (LDS, DIDA-Labs), the Agricultural Microbiology Laboratory (DAGRI), the Physical Chemistry Laboratory (DICUS), and the Methods and Techniques for Innovation Laboratory (DIEF).

The Biodesign Research Unit serves as a transdisciplinary space where approaches, languages, and tools from traditionally separate disciplines—design, biology, chemistry, materials science, and agricultural microbiology—converge. The primary goal of the unit is to develop research, projects, methods, and design tools shared across the various scientific-disciplinary sectors involved, capable, among other things, of bringing bio-informed design (Cantini, 2024) to a new level of technological maturity (TRL), from the experimental to the applicative stage. The transdisciplinary configuration of the Research Unit allows for a deeper and more conscious engagement with the critical phases of biofabrication experiments, such as organism selection, standardization of growth protocols, and evaluation of the physical, mechanical, and environmental properties of the resulting materials.

In parallel with the need to integrate different disciplinary cultures, progress in biofabrication research requires the creation of facilities equipped for advanced experimentation on biofabrication, growing materials (Langella, 2019), livingness, and living artifacts (Karana et al., 2020). Models such as the BlueCity Lab in Rotterdam or the Bio-Design Lab Hub for Biotechnology in the Built Environment (HBBE) demonstrate how well-equipped laboratories can foster the hybridization of knowledge. Many research centers are now moving in this direction, including the Cocoon project (Co-Creating Greener Futures, Designing Bio-Design Modules to Accelerate the Green Transition).

In this regard, the establishment of the Biodesign Lab at the Design Campus of the University of Florence represents a strategic response to this gap. Research spaces within Italian design universities are still primarily equipped with "hardware" and "software" tools but lack the "wetware" infrastructure necessary for working with living agencies. Supported by the Biodesign Research Unit, the Biodesign Lab will be operational from 2026 as an experimental laboratory within the University of Florence, conceived as a hybrid environment between a design lab and a bioscience lab. Within it, traditional tools such as 3D printers and computers will coexist with scientific equipment such as laminar flow hoods, incubators, shakers, hot plates, spectrophotometers, and optical microscopes.

This setup allows for the cultivation and safe manipulation of microorganisms (bacteria, yeasts, fungi, microalgae) under controlled conditions, opening new possibilities for direct experimentation on the biological behavior of materials.

Access to these tools enables biodesigners to gain deeper control over material processes, moving beyond the DIY approach (Rognoli et al., 2015). Material design thus becomes an active and controlled process, where the environmental conditions of experimentation (temperature, pH, nutrients, humidity, substrates, strains) are an integral part of the design process, directly influencing the form and final properties of the material or product. The laboratory will function as a true facility, open to all students, doctoral candidates, and researchers interested in interdisciplinary research, thereby bridging the gap between the theoretical potential of biodesign and its practical realization.

6 Towards a life-driven design paradigm

In the context of the material transition (Elhacham et al., 2020), biofabrication emerges as a strategic practice for contemporary design, capable of integrating biological processes into material design (Cleries et al., 2021).
This redefines the role of the designer and multiplies their design, production, technological, and expressive possibilities.
The biodesign laboratory can therefore be conceived as a super-instrument (super – meaning above), understood as a trigger for sustainable innovation, a collector of tools and facilities, and a place where disciplinary silos can be transcended and transgressed.
Since addressing the challenges of the material transition (Elhacham et al., 2020) and climate change requires transdisciplinary skills, new facilities can serve as platforms to trigger a life-driven paradigm shift in design.

Fig. 4 - INERTIAL project: A flask containing microalgae for the experimentations (Photo credits: Cristian Betti).

Fig. 5 - The Agricultural Microbiology Laboratory, an hub of the Biodesign Research Unit (Photo credits: Cristian Betti).

Note

[1] Coordinated by prof Marco Marseglia (Associate Professor, ICAR13). Members: Prof. Silvio Cristiano (RTDB, ICAR 21), Prof. Giuseppe Lotti (PO, ICAR13), Prof. Carlo Pisano (RTDB, ICAR 21),Prof. Gabriele Pontillo (RTDA, ICAR13), Francesco Cantini (PhD candidate, ICAR13), Edoardo Brunelli (PhD candidate, ICAR13), Tommaso Celli (research fellow, BIO/02), Alessio Tanzini (Tecnico di Laboratorio), Prof.ssa Natascia Biondi (AGR16), Prof. Massimo Bonini (CHIM02), Prof. Monica Tonelli (CHIM02), Prof. Federico Rotini (ING-IND/15)

[2] Funded by Cassa di Risparmio di Firenze e Next Generation EU, PI Prof. Marco Marseglia (DIDA, UNIFI) and Prof. Natascia Biondi (DAGRI, UNIFI), research group: Prof. Giuseppe Lotti, Francesco Cantini (PhD, research fellow), Tommaso Celli (research fellow), Edoardo Brunelli (PhD candidate), Lorenzo Reali (PhD candidate), Giacomo Sampietro (PhD, research fellow).

[3] Promoted by the Florentine University Incubator (IUF, UNIFI)

[4] Funded by R&S Regione Toscana, Coesione Italia 2021-2027

Author contribution statement

The text was developed collaboratively by Marco Marseglia and Francesco Cantini.

Referencing

Alemu, D., Tafesse, M., & Mondal, A. K. (2022). Mycelium-based composite: The future sustainable biomaterial. International journal of biomaterials, 2022.

Antonelli, P., & Tannir, A. (2019). Broken nature. Mondadori Electa.

Armiero, M. (2021). L'era degli scarti: Cronache dal Wasteocene. Giulio Einaudi.

Ahmad, W. A., Wan Ahmad, W. Y., Zakaria, Z. A., Yusof, N. Z., Ahmad, W. A., Ahmad, W. Y. W., ... & Yusof, N. Z. (2012). Application of bacterial pigments as colorant (pp. 57-74). Springer Berlin Heidelberg.

Benyus, J. M. (1997). Biomimicry: Innovation inspired by nature (Vol. 688136915). New York: Morrow.

Biondi, E., Rognoli, V., & Levi, M. (2009). Le neuroscienze per il design: la dimensione emotiva del progetto. Franco Angeli.

Camere, S., & Karana, E. (2018). Fabricating materials from living organisms: An emerging design practice. Journal of Cleaner Production, 186, 570-584.

Cantini, F. (2024). Design Toward the Biological Paradigm. Biologically Informed Design Strategies as a Driver for a Regenerative Future. https://hdl.handle.net/2158/1371454 (Tesi di dottorato)

Carullo, R., & Pagliarulo, R. (2018). Interior | Design. Action on Surfaces. Rubbettino

Cleries, L., Rognoli, V., Solanki, S., & Llorach, P. (2021). Material Designers. Boosting talent towards circular economies.

Crawford, A. (2023). Designer's Guide to Lab Practice. Routledge.

Cruz, M., & Beckett, R. (2016). Bioreceptive design: A novel approach to biodigital materiality. Arq: Architectural Research Quarterly, 20(1), 51-64.

Cruz, M., & Parker, B. (2022). From Anthropocene to Biocene: Novel Bio-Integrated Design as a Means to Respond to the Current Biodiversity and Climate Crisis. In Design Studio Vol. 4: Working at the Intersection (pp. 52-61). RIBA Publishing.

Elhacham, E., Ben-Uri, L., Grozovski, J., Bar-On, Y. M., & Milo, R. (2020). Global human-made mass exceeds all living biomass. Nature, 588(7838), 442-444.

Karana, E., Barati, B., Rognoli, V., & Zeeuw Van Der Laan, A. (2015). Material driven design (MDD): A method to design for material experiences. International journal of design, 9(2), 35-54.

Karana, E., Barati, B., & Giaccardi, E. (2020). Living Artefacts: Conceptualizing Livingness as a Material Quality in Everyday Artefacts. International Journal of Design, 14(3).

Kothari, V., Joshi, C., & Patel, P. (2016). Colourful side of bacteriology: the pigmented bacteria. Adv Genet Eng, 5, i104.

Langella, C. (2019). Design e scienza. ListLab

Lucibello, S., & Montalti, M. (2019). Beyond human–new Paradigms of active collaboration in Design| Oltre l'umano: nuovi Paradigmi di collaborazione attiva nel Design. DIID. DISEGNO INDUSTRIALE INDUSTRIAL DESIGN, (72), 26-34.

Lyle, J. T. (1996). Regenerative design for sustainable development. John Wiley & Sons.

Marseglia, M., Cantini, F., Celli, T., Brunelli, E., & Lotti, G. (2025). Transdisciplinary approach in biodesign: a case study of hybridization between design and scientific method in material design. Biotechnology Design, 4, e4. doi:10.1017/S2977905725100024

Marseglia, M., Biondi, N., Cantini, F., Celli, T., Brunelli, E., Reali, L., Sampiertro, G. (2025). Design, Materiali e relazioni interdisciplinari. In Progetti di ricerca Fonti e Risorse Convegno nazionale SID 2024.

Morton, T. (2013). Hyperobjects: Philosophy and Ecology after the End of the World. U of Minnesota Press.

Moroni, L., Boland, T., Burdick, J. A., De Maria, C., Derby, B., Forgacs, G., & Vozzi, G. (2018). Biofabrication: a guide to technology and terminology. Trends in biotechnology, 36(4), 384-402.

Myers, W. (2012) BioDesign. Nature, Science, Creativity. High Holborn, UK: Thames & Hudson

Narsing Rao, M. P., Xiao, M., & Li, W. J. (2017). Fungal and bacterial pigments: secondary metabolites with wide applications. Frontiers in microbiology, 8, 1113.

Pantanella, F., Berlutti, F., Passariello, C., Sarli, S., Morea, C., & Schippa, S. (2007). Violacein and biofilm production in Janthinobacterium lividum. Journal of applied microbiology, 102(4), 992-999.

Parisi, S., Rognoli, V., & Sonneveld, M. (2017). Material Tinkering. An inspirational approach for experiential learning and envisioning in product design education. The Design Journal, 20(sup1), S1167-S1184.

Pollini, B. (2024). From biodesigners to designers in lab: testing the nuances of an emerging profession through autoethnography. Research Directions: Biotechnology Design. 2024;2:e20. doi:10.1017/btd.2024.11

Qiu, J., Artier, J., Cook, S., Srubar, W. V., Cameron, J. C., & Hubler, M. H. (2021). Engineering living building materials for enhanced bacterial viability and mechanical properties. IScience, 24(2).

Reali, L., Sampietro, G., Cantini, F., Marseglia, M., & Biondi, N. (2022). Microalgae biomineralization to valorize stone extraction leftovers. In Conference AISAM 2022 Professor Mario Tredici (pp. 0–0). AISAM.

Reed, B. (2007). Shifting from 'sustainability' to regeneration. Building Research & Information, 35(6), 674-680.

Rognoli, V., Bianchini, M., Maffei, S., & Karana, E. (2015). DIY materials. Materials & Design, 86, 692-702.

Trebbi, L. (2024). Evolving Matter: the future of materials and design in the biofabrication era.

Wang, Y., Liu, Y., Li, J., Chen, Y., Liu, S., & Zhong, C. (2022). Engineered living materials (ELMs) design: From function allocation to dynamic behavior modulation. Current Opinion in Chemical Biology, 70, 102188.

Wahl D. C. (2022), L' arte di rigenerare il mondo. Come organizzare le nostre società per proteggere la vita sul pianeta, Aboca Edizioni.