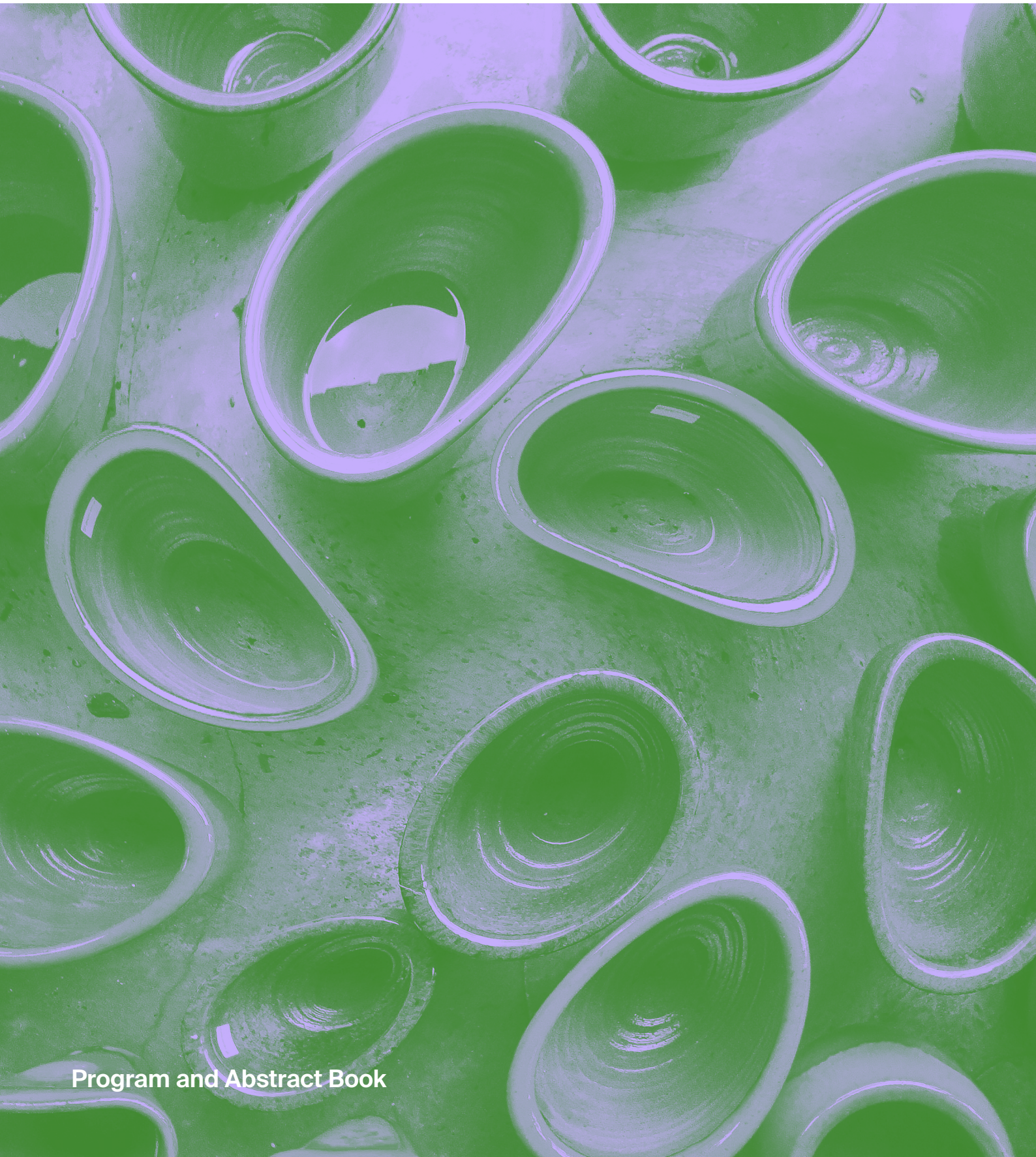
IOCB 2025 Conference

The 2nd International Online Conference on Biomimetics

16–18 September 2025 | Online



Program and Abstract Book

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The 2nd International Online Conference on Biomimetics

16–18 September 2025 | Online

MDPI

Organizing Committee

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Prof. Eduardo Miranda
Prof. Georgios Sirakoulis
Prof. Phil Ayres
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Welcome from the Chair

Dear Colleagues,

We invite researchers, practitioners, and thought leaders in biomimetics to submit papers for the upcoming Biomimetics Conference 2025. This interdisciplinary conference will explore the frontiers of bioinspired technologies and systems, bringing together expertise from diverse fields to examine how nature's principles can inform and revolutionize modern science, engineering, and design.

The conference will feature the following main sessions and welcomes submissions on these and related topics:

S1. Bioinspired Electronics

Examples include nature-inspired electronic materials and components; flexible, stretchable, and wearable electronics; self-healing circuits and biohybrid devices; and energy-efficient electronic designs modeled after biological systems.

S2. Bioinspired Computing—Algorithms and Prototypes

Examples include computational algorithms derived from biological processes, including neural, evolutionary, or swarm algorithms; prototype computing devices inspired by biological structures; neuromorphic computing, artificial intelligence, and machine learning using biomimetic approaches; and bioinspired data processing and memory storage techniques.

S3. Bioinspired Materials—Structures, Surfaces, and Interfaces

Examples include the development of materials inspired by biological structures (e.g., lotus effect surfaces, spider silk-inspired fibres); interfaces and coatings mimicking biological surfaces; structural materials inspired by nature's resilience and efficiency; and applications in medical, aerospace, and environmental sciences.

S4. Bioinspired Architecture and the Built Environment

Examples include sustainable building designs and materials influenced by biological systems; adaptive and responsive architectural systems; structural optimization based on natural forms; and biomimetic urban planning and green infrastructure.

S5. Bioinspired Robotics

Examples include robotics inspired by animal and plant biomechanics; autonomous and self-repairing robots; soft robotics, biomimetic actuators, and sensors; and swarm robotics and cooperative robotic systems.

S6. Bioinspired Arts

Examples include bioinspired music; art installations and visual arts inspired by biomimicry; bioinspired design in fashion, textiles, and product design; cross-disciplinary collaborations between art, science, and technology; and interactive and multimedia art influenced by natural systems.

We encourage submissions of original research, case studies, design prototypes, and conceptual frameworks that address any of the topics listed above. Submissions will be peer-reviewed by experts in the field, with selected papers being presented during the conference sessions and considered for publication in the conference proceedings.

Join us at the Biomimetics Conference 2025 to exchange insights, showcase innovations, and explore the future of bioinspired technology. Let nature inspire your next breakthrough!

Prof. Dr. Andrew Adamatzky
Conference Chair
Unconventional Computing Laboratory, University of the West of England (UWE), Bristol, UK

biomimetics
an Open Access Journal by MDPI

Biomimetics (ISSN 2313-7673) is an open access journal regarding biomimicry and bionics, dedicated to research that relates to the most basic aspects of living organisms and the transfer of their properties to human applications. The journal aims to provide a forum and a survey for researchers and professionals in the fields of materials science, mechanical engineering, nanotechnology and biomedicine interested in exploiting biologically inspired designs in engineering systems, technology and biomedicine aimed to developing novel solutions that enable sustainable innovation.

Journal Webpage: https://www.mdpi.com/journal/biomimetics

Session Chairs

Prof. Georgios Sirakoulis

Department of Electrical and Computer Engineering, Democritus University of Thrace, Komotini, Greece

Prof. Dr. Andrew Adamatzky

Unconventional Computing Laboratory, University of the West of England (UWE), Bristol, UK

Prof. Victor Erokhin

Institute of Materials for Electronics and Magnetism, Italian National Council of Researches (IMEM-CNR), Parma, Italy

Prof. Phil Ayres

Royal Danish Academy, Copenhagen, Denmark

Prof. Alessandro Chiolerio

Istituto Italiano di Tecnologia (IIT), Genova, Italy; University of the West of England (UWE), Bristol, UK

Prof. Eduardo Miranda

School of Art, Design and Architecture, Plymouth University, Plymouth, UK

Invited Speakers

Prof. Julian Vincent
Department of Mechanical Engineering, Heriot-Watt University, Edinburgh, UK

Prof. Dr. Alex James
Department of Electronics and Communication Engineering, Digital University Kerala, Veiloor, India

Prof. Vasilis Ntinas
Edge Computing and Networking Group, Department of Electronic Systems, Aalborg University, Copenhagen, Denmark

Prof. Gleb Sukhorukov
Queen Mary University of London, London, UK

Assoc. Prof. Assia Crawford
College of Architecture and Planning, University of Colorado Denver, Denver, USA

Assoc. Prof. Richard Beckett
The Bartlett School of Architecture, University College London, London, UK

Prof. Konrad Szaciłowski
AGH University of Technology, Kraków, Poland

Dr. Heather Barnett
Central Saint Martins, University of the Arts London, London, UK

Dr. Luca Forcucci
Independent Artist, Berlin, Germany

Dr. Dan Nicolau
King's College London, London, UK

Prof. Laura Pastorino
Department of Informatics, Bioengineering, Robotics and Systems Engineering (DIBRIS), University of Genoa, Genoa, Italy

Dr. Neil Phillips
School of Computing and Creative Technologies, University of the West of England (UWE), Bristol, UK

Program Overview

	DAY 1	DAY 2	DAY 3
Morning	**16 September (10:00–11:55 CEST)**	**17 September (10:00–12:55 CEST)**	**18 September (10:00–12:15 CEST)**
	S1: Bioinspired Electronics	S3: Bioinspired Materials—Structures, Surfaces and Interfaces	S4: Bioinspired Architecture
	Lunch Break		
Afternoon	**16 September (14:00–15:40 CEST)**	**17 September (14:00–16:15 CEST)**	**18 September (14:00–16:10 CEST)**
	S6: Bioinspired Arts	S5: Bioinspired Robotics	S2: Bioinspired Computing—Algorithms and Prototypes
Flash Poster Session	**Poster Session** S1 + S6	**Poster Session** S3 + S5	**Poster Session** S4 + S2

IOCB 2025 Program

16 September 2025 (Day 1)

Session 1. Bioinspired Electronics

Time: 10:00 (CEST, Basel) | 09:00 (BST, UK) | 16:00 (CST Asia, Beijing)

CEST Time	Speaker	Title
10:00-10:10	**Prof. Dr. Andrew Adamatzky** Event Chair	Introduction to IOCB2025
10:10–10:40	**Prof. Julian Vincent**	Opening Speech: On Biomimetics
10:40–10:55	**Prof. Georgios Sirakoulis** Session Chair	Welcome from Session Chair
10:55–11:10	**Prof. Dr. Alex James** Invited speaker	The universal computing machines: extended possibilities with analog neural-memristive networks.
11:10–11:25	**Prof. Vasileios Ntinas** Invited speaker	A Phoenix in the Making: Memristors and the Resurgence of Cellular Nonlinear Networks.
11:25–11:35	**Maria Lok-Yee Li** Selected Oral Speaker	Phytonet: A Phytoplankton-powered Biobattery for Regenerative, Low-Power Internet Infrastructure
11:35–11:45	**Enver Salkim** Selected Oral Speaker	Evaluating Cochlear Dielectric Effects on Impedance-Based Electrode Insertion Guidance
11:45–11:55	**Jakub Szpara** Selected Oral Speaker	Self-Healing Electro-Stimulating Implants – A Step Toward Regenerative Neurology
11:55–14:00	**Lunch Break**	

Session 6. Bioinspired Arts

Time: 14:00 (CEST, Basel) | 13:00 (BST, UK) | 20:00 (CST Asia, Beijing)

CEST Time	Speaker	Title
14:00–14:15	**Prof. Eduardo Miranda** Session Chair	Welcome from Session Chair
14:15–14:30	**Dr. Heather Barnett** Invited speaker	Drawing out the superorganism: amplifying the processes of life through artistic intervention
14:30–14:45	**Dr. Luca Forcucci** Invited speaker	Internal Environments and Meta structures
14:45–14:55	**Silvia Titotto** Selected Oral Speaker	Living Systems, Moving Bodies: Bioinspired Choreographic Processes in Contemporary Dance
14:55–15:05	**Ille C. Gebeshuber** Selected Oral Speaker	Galls, Genes and Growing Devices: Bioinspired Art and the Vision of Programmable Plants
15:05–15:15	**Amir Bastan** Selected Oral Speaker	MycoGravity: A Robotic Installation for Observing Fungal Growth Under Altered Gravity Conditions
15:15–15:25	**Noor Stenfert Kroese** Selected Oral Speaker	ZOE: Real-Time Interaction Between Reishi Mushrooms and custom-made Robotic System
15:25–15:30	**Nariman Lotfi** Selected Poster Speaker	Bio-informed design in practice: Are current processes aligning with the needs from practice?
15:30–15:35	**Maria Crina Isac** Selected Poster Speaker	Biomimetic Artistic Representation of Histological Tissue Morphology: A Scientific Approach to Visualizing Cellular Structures in Contemporary Visual Art

17 September 2025 (Day 2)

Session 3. Bioinspired Materials—Structures, Surfaces and Interfaces

Time: 10:00 (CEST, Basel) | 09:00 (BST, UK) | 16:00 (CST Asia, Beijing)

CEST Time	Speaker	Title
10:00–10:15	**Prof. Victor Erokhin** Session Chair	Welcome from Session Chair
10:15–10:30	**Prof. Gleb Sukhorukov** Invited speaker	Coating with programmed drug release for implantable medical devices
10:30–10:45	**Prof. Laura Pastorino** Invited speaker	Advanced in vitro models of brain tissue for neurotechnology
10:45–10:55	**Syeda Zahra** Selected Oral Speaker	Biomimetic Scaffold Design for Retinal Tissue Engineering: A Novel Approach to Treat Retinal Degenerative Diseases
10:55–11:05	**Akash Kaul** Selected Oral Speaker	What do Physarum cosmoldogists think about how nearby galaxies are connected?
11:05–11:15	**Zuzanna Ewa Kaczmarska** Selected Oral Speaker	From mussels to muscles: A Bioinspired Film that Contracts in Response to Light
11:15–11:25	**Vitaliy Nikolaevich Soromotin** Selected Oral Speaker	Encapsulated bacteria-supported palladium nanoparticles in sol-gel material as core-shell catalyst for the Mizoroki-Heck reaction
11:25–11:35	**Turgut Batuhan Baturalp** Selected Oral Speaker	Development, Evaluation, and Validation of a Realistic Simulator for the Human Left Ventricle
11:35–11:45	**Riccardo Carlo Moroni** Selected Oral Speaker	Comparison between different auxetic geometry for mimicking tendon mechanical properties
11:45–11:55	**Darya Nikolaevna Zinovyeva** Selected Oral Speaker	Bioactive wound-healing hydrogel porphyrin-containing systems based on polycation-stabilized alginates
11:55–12:05	**Richard Wilhelm van Nieuwenhoven** Selected Oral Speaker	Biomimetics and sustainability: rethinking nature-inspired design
12:05–12:15	**Mikhail Savelyev** Selected Oral Speaker	Bioinspired composite: influence on electrical conductivity of carbon nanotubes with different hydrodynamic radii in photoresist
12:15–12:25	**Silvia Battistoni** Selected Oral Speaker	Electrochemical approach for the realization of OECTs: a polypyrrole case study
12:25–12:35	**Gaurab Sundar Dutta** Selected Oral Speaker	Enhancing Compressive Performance of Gyroid Structures Through Evolutionary Design
12:35–12:45	**August Hammel** Selected Oral Speaker	A Basic Framework for Bioinspired Design and Optimization of a Bone-Integrated Prosthesis for Equines
12:45–12:55	**Polina M. Tyubaeva** Selected Oral Speaker	A novel approach to the creation of biomimetic materials for accelerated wound healing based on modified biopolymers
12:55–14:00	**Lunch Break**	

Session 5. Bioinspired Robotics

Time: 14:00 (CEST, Basel) | 13:00 (BST, UK) | 20:00 (CST Asia, Beijing)

CEST Time	Speaker	Title
14:00–14:15	**Prof. Alessandro Chiolerio** Session Chair	Welcome from Session Chair
14:15–14:30	**Dr. Neil Phillips** Invited speaker	Marimo Robots
14:30–14:40	**Tianyi Zhang** Selected Oral Speaker	An analysis of the dynamic metastasis mechanism in liver cancer cells based on a biomimetic microfluidic vascular network
14:40–14:50	**Yashvardhan Shahu Mote** Selected Oral Speaker	Bio-Inspired Underwater Robots
14:50–15:00	**Marvin Cheng** Selected Oral Speaker	Pollination process with collaborative robotic platform

15:00-15:05	**Elizaveta Lantsova** Selected Poster Speaker	The use of chloropropyltriethoxysilane in combination with biotemplates for the formation of a functionalized organosilicon material
15:05-15:10	**Dmitriy Eduardovich Voytsekhovskiy** Selected Poster Speaker	Preparation and characterization of alginate/hyaluronate hydrogel incorporating zoledronic acid-loaded chitosan microparticles for osteoarthritis therapy
15:10-15:15	**Xu Chen** Selected Poster Speaker	Developmental Trajectory of Jumping Ability in Lycorma delicatula
15:15-15:20	**Rui Liu** Selected Poster Speaker	Anolis carolinensis exhibits background-dependent, spectrally refined camouflage: chromatic shift dynamic principles and biomimetic potential
15:20-15:25	**Ankita Sharma** Selected Poster Speaker	Preparation and Characterization of Kombucha-Derived Bacterial Cellulose for Advanced Antimicrobial Biomaterials
15:25-15:30	**Jeong-Mo Yang** Selected Poster Speaker	Fractal Architecture as a Foundational Design Principle in Biomimetic Material Engineering
15:30-15:35	**Jovana Acimovic** Selected Poster Speaker	In Silico Assessment of Natural Biodegradable Polymers for Dermal Drug Delivery Systems
15:35-15:40	**Chaymaa Hachimi Alaoui** Selected Poster Speaker	Integration of 3D Bioprinting in Bone Tissue Engineering Using Chitosan Hydrogels: Preliminary Experiments Based on Formulation and Characterization of Three Chitosan Hydrogels
15:40-15:45	**Debela Negasa Gurmu** Selected Poster Speaker	Faculty of Materials Engineering, Department of Materials Technologies, Silesian University of Technology
15:45-15:50	**JiaHui Hu** Selected Poster Speaker	Characteristics of Iridophore Crystals in Anolis carolinensis
15:50-15:55	**Nutan Rakeshkumar Shukla** Selected Poster Speaker	Simultaneous Targeted Isolation and Controlled release of Circulating Tumor Cells (CTCs) using a photothermal scaffold-embedded microfluidics system
15:55-16:00	**Taisiya Bolkhovskaya** Selected Poster Speaker	Bioinspired Sn-Substituted Hydroxyapatite for Dental Desensitization: Structural Insights and Synthesis Optimization
16:00-16:05	**Eduardo Favret** Selected Poster Speaker	How the cuticle of soil-digging beetles can help us achieve non-stick surfaces for soil tillage tools: a review
16:05-16:10	**Jessica Martínez Jiménez** Selected Poster Speaker	Phage-formed liquid crystal fiber biotemplates for material synthesis
16:10-16:15	**Olga Kamanina** Selected Poster Speaker	The biosynthesis of palladium nanoparticles by microorganisms and their relationship with biomimetic structures

18 September 2025 (Day 3)

Session 4. Bioinspired Architecture

Time: 10:00 (CEST, Basel) | 09:00 (BST, UK) | 16:00 (CST Asia, Beijing)

CEST Time	Speaker	Title
10:00–10:15	**Prof. Phil Ayres** Session Chair	Welcome from Session Chair
10:15–10:30	**Prof. Assia Crawford** Invited speaker	Directed Hyphal Growth in Ganoderma lucidum via Magnetic and Radio Frequency Stimuli
10:30–10:45	**Prof. Richard Beckett** Invited speaker	Advanced in vitro models of brain tissue for neurotechnology
10:45–10:55	**Asif Hasan Zeshan** Selected Oral Speaker	Uncoding the Biomorph: A Post-Algorithmic Approach to Bioinspired Architectural Design Intelligence
10:55–11:05	**D. Ben Ghida** Selected Oral Speaker	Astroarchitecture
11:05–11:15	**Niranjika Wijesooriya** Selected Oral Speaker	Biophilic Design for Sustainability: Development of a Design Framework Using Bio-inspired Processes
11:15–11:25	**Julia Grochowska** Selected Oral Speaker	A Conceptual Framework for an Allelopathic Cultivation Garden: Nature-Inspired Foundations for Sustainable Horticulture
11:25–11:35	**Qi Luo** Selected Oral Speaker	Exploring Living Architectures with Microbial Cement Supercapacitors
11:35–11:45	**Omar Borham** Selected Oral Speaker	Development of Biomimetic Strategy-focused, Decision-Support Tool for Regenerative Urban and Architectural Planning
11:45–11:55	**Afifah Nawshin Tabassum** Selected Oral Speaker	The Vein Logic: Designing Smarter Drainage Systems Inspired by Nature
11:55–12:05	**Asya Ilgün** Selected Oral Speaker	Tejiendo con Seres de la Tierra: Co-Weaving a Biohybrid Mishki Wasi with Kuriñampi and Samaruta for the Living Forest (Kawsak Sacha) of the Amazon
12:05–14:00	**Lunch Break**	

Session 2. Bioinspired Computing—Algorithms and Prototypes

Time: 14:00 (CEST, Basel) | 13:00 (BST, UK) | 20:00 (CST Asia, Beijing)

CEST Time	Speaker	Title
14:00–14:15	**Prof. Dr. Andy Adamatzky** Session Chair	Welcome from Session Chair
14:15–14:30	**Prof. Konrad Szaciłowski** Invited speaker	From crystal engineering to pattern recognition. A story on bismuth complexes
14:30–14:45	**Dr. Dan Nicolau** Invited speaker	Why do we have an (adaptive) immune system?
14:45–14:55	**Abdelrahman Wael Ammar** Selected Oral Speaker	Deep Learning-Guided Optimization of Electrode Insertion Trajectories Using Impedance Feedback in Cochlear Implants
14:55–15:05	**Darija Obradovic** Selected Oral Speaker	GNN: bioinspired algorithm for predicting biomimetic molecular characteristics
15:05–15:15	**Gavriil Alexandrovich Kupriyanov** Selected Oral Speaker	Gender Supremacy: A theoretical demonstration of gender genetic algorithm's superiority over standard genetic algorithm using schema theory
15:15–15:25	**Robert Anthony Clarke** Selected Oral Speaker	Evaluating Calictron and Expressive Leaky Memory Recurrent Units for Echo State Networks
15:25–15:35	**Wiktoria Florek** Selected Oral Speaker	Insect-inspired pattern recognition algorithms for ECG signal analysis
15:35-15:40	**Carlos Emmanuel P. Garcia** Selected Poster Speaker	Transonic Aerodynamic Performance of a NACA 0012 Airfoil with a Leading Edge Inspired by Humpback Whale Tubercles
15:40-15:45	**Kachana Kasulu** Selected Poster Speaker	Neuromorphic Generative Design: Brain-Inspired Computing Workflows for Self-Adaptive Building Façades
15:45-15:50	**Olga Volichenko** Selected Poster Speaker	Phototropic-Inspired Neural Growth Algorithms for Adaptive Timber Canopies

15:50-15:55	**Russel Aeron P Santos** Selected Poster Speaker	The Permeability of a Soil Termite [Macrotermes gilvus (Hagen, 1858)] Fungus Comb as a Porous Medium
15:55-16:00	**Olusegun Aanuoluwapo Oguntona** Selected Poster Speaker	The Transformative Potential of Biomimicry for Sustainable Construction: An Exploratory Factor Analysis of the Benefits
16:00-16:05	**Mannat Chopra** Selected Poster Speaker	Biomimetic Distribution Systems: Investigating the Building of Water Supply Systems Through A Study of the Xylem Network
16:05-16:10	**Amit Kumar Jaglan** Selected Poster Speaker	Exploring Adaptive Building Façade Designs Inspired by Natural Systems: A Literature Review and Prospective Application for Energy Efficiency in Indian Architecture

Session 1. Bioinspired Electronics

sciforum-129145: Phytonet: A Phytoplankton-powered Biobattery for Regenerative, Low-Power Internet Infrastructure

Maria Lok-Yee Li [1,*] and Lorraine Archer [2]

[1] MA Biodesign, Central Saint Martins, University of Arts London, UK
[2] Living Systems Lab, Central Saint Martins, University of Arts London, UK

The rapid growth of internet infrastructure, driven by IoT, cloud computing, and machine learning, has led to a surge in global energy consumption, projected to increase by 9% annually. As digital networks become increasingly resource-intensive, there is a critical need to explore novel regenerative design strategies beyond mitigation, which actively contribute to the resilient functioning of ecological systems. This study presents Phytonet, a bioinspired physical manifestation of a regenerative internet infrastructure powered by biophotovoltaic (BPV) systems using photosynthetic microorganisms sourced from urban waterways. By integrating energy harvesting, carbon capture, and low-power internet hardware into a single system, the floating BPV-powered web server embodies a shift from extractive to reciprocal models of infrastructure.

A transdisciplinary approach was used to evaluate the technical performance and socio-ecological potential of BPV-powered electronic systems. Enriched phytoplankton cultures from London's Regent's Canal were inoculated on modular floating BPV units that were designed for flexible configuration and constructed from widely available materials. Devices were tested under laboratory and canal conditions. Real-world stakeholder engagement through scenario-building and interviews uncovered user perceptions and speculative applications, contributing to an understanding of how BPV-powered electronics might function as regenerative, community-integrated infrastructure.

The open flat plate configuration yielded a peak power output of 3.4 mW per module and a current density of 896.8 mA/m^2 after 30 days of operation, indicating its feasibility for powering remote low-energy electronics, such as sensors or microcontrollers in IoT applications. To contextualise the design within broader social and ecological systems, we developed a speculative floating BPV-powered web server and deployed cultural probes to explore public imaginaries of a photosynthesis-powered internet. Community responses highlighted potential applications, including environmental sensing IoT systems and biodiversity enrichment in waterways.

This research demonstrates the potential of biophotovoltaic-powered systems as a novel class of bioinspired electronics that are not only energy-generating but also ecologically integrative. By embedding photosynthetic energy harvesting into distributed digital infrastructure, Phytonet exemplifies how electronics can operate in synergy with living systems—harvesting ambient resources, supporting biodiversity, and serving low-power applications such as IoT sensing

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sciforum-130360: Biomimetic solid-state FET nanopores for enhanced molecular sensing: learning from transmembrane peptides

Irina Karpushkina *, Pavel Shestun, Alexander Silyuk and Vadim Gvozdev

ITMO University

Introduction

Biological ion channels, particularly transmembrane pores involved in peptide transport, demonstrate exquisite molecular selectivity and dynamic gating. These properties, essential to processes like antigen presentation or viral genome delivery, provide a blueprint for advanced biosensors. Yet, biological nanopores, while sensitive, lack mechanical stability and integration capability. Solid-state nanopores offer robustness and scalability but suffer from low signal-to-noise ratios (SNR) and ultrafast analyte translocation. Inspired by biological translocation mechanisms and channel-gated sensing, we are focusing on a biomimetic solution: a nanopore integrated with a field-effect transistor (NP-FET) based on SiN membranes.

Methods

Our approach mimics the localized field interactions observed in natural peptide translocation by coupling molecular passage through a 2 nm Si_3N_4 pore with FET modulation. Using molecular dynamics (MD) simulations (NAMD with CHARMM27 force fields), we analyzed the electrophoretic transport of synthetic peptides (e.g., PolyAsp, Gly(14)-Phe-Gly(15)) under variable voltages, assessing their velocity, field response, and ability to modulate transistor current.

Results

Simulations revealed strong charge- and volume-dependent transport phenomena. Highly charged peptides like PolyAsp translocated within 0.3 ns, underscoring the need for signal amplification—achievable via NP-FET coupling. In contrast, bulky hydrophobic peptides (e.g., PolyPhe) showed no translocation even under high voltage, aligning with biological channel exclusion behavior. Voltage-current profiles varied significantly across peptides, revealing potential for sequence-specific signal fingerprints.

Conclusions

Our findings validate a biologically inspired FET nanopore architecture that enhances SNR and enables molecular fingerprinting of peptides. This biomimetic approach leverages nature's design principles—charge gating, selective translocation, and conformational filtering—toward solid-state platforms for sequencing and biosensing. This paves the way for future low-cost, label-free, and integratable diagnostics informed by biological transport efficiency.

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sciforum-130092: Evaluating Cochlear Dielectric Effects on Impedance-Based Electrode Insertion Guidance

Enver Salkim [1,*], Halil Seymen [2] and Tayfun Abut [3,1,9,6]

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[2] Technical Sciences Vocational High School, Muş Alparslan University, 49100, Muş, Turkey
[3] Department of Mechanical Engineering, Muş Alparslan University, 49100 Muş, Turkey

Introduction

Cochlear neuromodulators play a significant role in restoring auditory perception for individuals with hearing impairments. A key factor in their effectiveness is the precise placement of the electrodes within the cochlea, as incorrect insertion can result in additional tissue damage. One method for assisting accurate electrode positioning involves measuring impedance, which can serve as a useful indicator during insertion.

Methods

Advanced bio-computational techniques offer a viable way to explore how the dielectric properties of different cochlear tissue layers influence impedance measurements—something that is difficult or impractical to study directly in cochlear implant (CI) patients. Although earlier modeling studies have often dismissed the capacitive characteristics of these tissues using the quasi-static (QS) approximation, it is well understood that biological tissues exhibit frequency-dependent filtering effects. As a result, the QS approximation may not always be sufficient, particularly when short-duration electrical pulses are involved. This study focused on examining how frequency-dependent dielectric properties of the cochlear tissues affect impedance measurements during electrode insertion. A volume conductor model representing the layered structure of the cochlea was developed, and the dielectric properties of each layer were obtained.

Results

Using cochlear neuromodulator parameters, simulations were carried out employing both the QS and transient solution (TS) methods. The outcomes from each method were compared to assess how the dielectric properties influenced the impedance results.

Conclusions

The findings suggest that above a certain frequency threshold, the capacitive effects of the cochlear tissues become significant and should be taken into account for accurate modeling.

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sciforum-142414: Self-Healing Electro-Stimulating Implants – A Step Toward Regenerative Neurology

Jakub Szpara

University of Rzeszów, Collegium Medicum, Faculty of Medicine

Introduction

Electrostimulation is emerging as a promising therapeutic alternative for the treatment of neurological injuries, as well as dysfunctions of the visceral and musculoskeletal systems. Limitations of the conventional implants—including stiffness, degradation, the need for surgical removal, and external power sources—have driven the development of bioinspired solutions that integrate flexibility, a self-healing capacity, and biodegradability.

Methods

A literature review was conducted for the years 2020–2025 using the PubMed, Google Scholar, and ResearchGate databases, with the keywords *self-healing polymers*, *implantable electrostimulation*, *bioelectronics*, *neurorepair*, *visceral stimulation*, and *biodegradable electronics*. The inclusion criteria focused on original studies and reviews concerning implantable, self-healing electrostimulation systems tested in biological models.

Results

The identified studies show rapid advancements in materials and systems that combine electrical, mechanical, and biological functions. Notably, implants made from conductive polymers (e.g., PEDOT) demonstrated self-healing capabilities under physiological conditions, maintaining electrical conductivity after repeated mechanical damage. In visceral neurostimulation models, such implants proved compatible with dynamic organ movements and were able to support neuromuscular functions over extended periods. Additionally, a biodegradable implant based on a triboelectric nanogenerator (TENG), activated by body motion, significantly accelerated bone healing in rats, resulting in a 27% increase in bone mineral density and an 83% improvement in mechanical strength after 6 weeks. Complementary systems combined sensory, mechanical, and stimulation functionalities within a single flexible structure that responded autonomously to motion.

Conclusions

Next-generation electrostimulation implants—self-healing, elastic, and bioresorbable—offer transformative potential in regenerative neurology and functional medicine. Their ability to adapt within dynamic biological environments makes them highly promising for treating both central and peripheral nervous system disorders while reducing the need for reoperations and improving patient safety and comfort.

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Session 2. Bioinspired Computing—Algorithms and Prototypes

sciforum-134132: Evaluating Calictron and Expressive Leaky Memory Recurrent Units for Echo-State Networks

Robert Anthony Clarke *, Dingguo Zhang and Damien Coyle

University of Bath

Reservoir computing offers a fast, low-power route to modelling rich temporal signals, yet the field still lacks principled guidance on how depth, neuron model, and architectural homogeneity influence performance. We therefore explored a family of bio-inspired, sequential reservoir chains that progressively combine echo-state networks (ESNs) with different types of recurrent units. These recurrent units consisted of recently developed neuron models—the Calcitron and Expressive Leaky Memory Neuron (ELM)—along with standard recurrent neurons.

ESNs containing these differing recurrent units were evaluated with different deep architectures against different time-series data types. We investigated a 1-layer sole reservoir, a 5-layer chain, and a 10-layer chain—each with homogeneous reservoirs—and evaluated different connection methods to examine their impact in creating DeepESNs.

Each reservoir comprised equal numbers of neurons fed by a standardised sparse connectome. All models were benchmarked on memory–capacity curves, dynamic-range analyses, chaotic time-series prediction (Mackey–Glass, Lorenz) and noisy-signal reconstruction on real and synthetic, biologically relevant signal types, such as chips, random walks, and time–frequency spectra, using identical data pipelines and linear read-outs. The dynamics of the ESNs were evaluated through calculations of their dynamical properties and numerical comparisons of their lower-dimensional manifolds. Interestingly, there was no clear overall best model when only changing neuron type, with each model showing superior performance on some data types but failing on others. Additionally, with regard to ELM and Calcitron models, light parameter tuning was shown to be beneficial to improve performance, given the parameter-rich equations that underlie these neuron models.

In conclusion, we present two new architectures for echo-state networks that use different neuron models for their recurrent units and evaluate their dynamics and performance on a battery of time-series tasks, showing that these models are able to achieve superior performance in a selection of these tasks when tuned correctly and when weights are not left static.

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sciforum-127798: Deep Learning-Guided Optimization of Electrode Insertion Trajectories Using Impedance Feedback in Cochlear Implants

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Cochlear implants represent a critical intervention for individuals with severe-to-profound sensorineural hearing loss. However, surgical insertion of the electrode array remains a challenging procedure where suboptimal trajectories can result in intracochlear trauma, scala translocation, and compromised auditory outcomes.

This paper presents a novel methodology that integrates real-time impedance feedback with spatiotemporal deep learning models to optimize electrode insertion trajectories during cochlear implant surgery. We developed a Spatiotemporal Graph Neural Network (ST-GNN) trained on COMSOL Multiphysics simulation data representing impedance responses across various electrode positions and cochlear anatomies. To enhance robustness and clinical safety, the proposed hybrid system combines the ST-GNN with a classical Decision Tree Classifier.

Our experimental results demonstrate a trajectory prediction accuracy of 94.6%, with trauma risk classification achieving an F1-score of 0.909. The system maintains spatial precision within 0.28 mm depth deviation and 1.42° angular deviation from optimal paths, meeting clinical tolerance requirements. The proposed ST-GNN achieved an MSE of 0.041, representing a 29.3% improvement over the next-best-performing method (GraphSAGE). The hybrid system further reduced the MSE to 0.037, demonstrating the effectiveness of classical AI integration.

Clinical validation scenarios show a 96.3% trauma prevention rate. Real-time inference capabilities with an average latency of 12.3 ms support intraoperative deployment. This approach provides a scalable, autonomous tool for real-time surgical guidance that could significantly improve cochlear implant outcomes.

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sciforum-130408: Transonic Aerodynamic Performance of a NACA 0012 Airfoil with a Leading Edge Inspired by Humpback Whale Tubercles

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The growing interest in biomimicry in flow control has created opportunities for more innovative designs. Humpback whale tubercles are particularly distinctive. This biomimetic modification in airfoils has been extensively studied in the subsonic regime and is well known for its ability to delay stall. However, it has not received the same level of engineering attention as transonic flow. The purpose of this study is to determine whether the stall-delaying effect persists in the transonic regime and to evaluate its performance as the amplitude of the tubercles increases. Six configurations were tested, with amplitude-to-chord length (c) ratios ranging from 0.025 to 0.25. A simulation study was conducted using ANSYS Fluent and the SST k-ω turbulence model to determine the aerodynamic performance. The configuration with the smallest tubercle amplitude (0.025c) outperformed the others. It reduced drag significantly (30% at Mach 0.8) and improved the lift-to-drag ratio (CL/CD) from l° to 3° AoA (+37.8% at 1° AoA) when compared to the baseline. Tubercles were found to influence shock structures, with valleys and peaks tending to weaken or delay them. Increasing tubercle amplitude beyond this optimum (beyond 0.1c) generally resulted in performance degradation, including lower lift, increased drag (0.25c configuration exhibited up to 40% more drag than the baseline at Mach 0.9), and adverse flow phenomena such as intensified shock–boundary layer interactions, flow separation, and more chaotic vortex formation. This study suggests that leading-edge tubercles could be used in high-speed flight.

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sciforum-133679: Gender Supremacy: A theoretical demonstration of gender genetic algorithm's superiority over standard genetic algorithm using schema theory

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Genetic algorithm (GA) is a highly popular derivative-free optimization method that is widely used in real-world tasks. There are numerous studies on GA modifications aimed at improving its search efficiency. Gender GA (GGA) is one of them. GGA divides a population into two parts (genders) with high and low mutation rates, and constrains the crossover of individuals of the same gender.

Typically, all new modifications of GGA are validated with computational experiments on a list of problems. This provides practical knowledge about the performance of new modifications, but not a general understanding of the effectiveness of gender introduction. In this study, we consider binary-coded GGA using Holand's schema theory. Comparison of the growth values for different schemata orders $o(H)$ shows GGA's superiority over standard GA. This result does not require problem specification and represents theoretical evidence of GGA's supremacy over GA.

Another interesting result of this study lies in the field of biology: the observed superiority of GGA over GA may indicate an advantage of genderized species over non-genderized species. Along with the Red Queen hypothesis, this can be treated as an additional explanation of the advantage of sexual reproduction. However, since GGA represents a highly simplified version of the biological evolution process of genderized species, it should be treated with some skepticism, and requires further investigation.

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sciforum-127894: GNN: bioinspired algorithm for predicting biomimetic molecular characteristics

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Information about the behavior of molecules in living organisms and the environment can be obtained by preliminary characterization of their biomimetic profile. The biomimetic profile may include the physico-chemical, pharmacokinetic, and ecotoxicological properties of the experimental molecule, determining its practical potential. This approach is widely used in pharmaceutical-oriented disciplines because it directs the further development phase of drugs. In our study, the possibility of applying graph neural networks (GNNs) as a bio-inspired algorithm for predicting Hansen's solubility parameters (HSPs) of molecules was examined. Hansen's solubility parameters consider the characteristics of molecules through the contributions of hydrogen, dispersive, and polar forces. By predicting and understanding these physico-chemical characteristics, the pharmacokinetic profile of the compound and its toxicological potential can be predicted. The best models were selected according to the internal (R^2_{train}, RMSE, MEPcv) and external (RMSEP, CCC, MEP, R^2_{test}, ar^2m, Δr^2m) validation metrics using a freely available database, https://www.stevenabbott.co.uk. In addition, experimental validation was performed considering the agreement between experimentally obtained HSP data from the literature for 93 compounds and the data predicted by the created models. The results of GNN modeling showed reliable predictive characteristics. For polar and hydrogen bond forces, the coefficient of determination between experimentally obtained and predicted HSP values was greater than 0.76, and for dispersive forces it was greater than 0.66. The created GNN models can be successfully applied in characterizing the biomimetic properties of experimental molecules in preliminary drug profiling.

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sciforum-136604: Insect-inspired pattern recognition algorithms for ECG signal analysis

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Introduction

Accurate analysis of electrocardiogram (ECG) signals is crucial for early and effective detection of many heart abnormalities and diseases. Traditional machine-learning techniques have shown promise; however, they often require complex architectures and may struggle with complex, broad biomedical data that often includes artifacts and other abnormalities.

Bioinspired intelligence algorithms such as Ant Colony Optimization (ASO) offer more lightweight, adaptive alternatives, inspired by the adaptive intelligence of ants observed over the years. ACO has shown significant potential in enhancing feature extraction and classification in ECG signal processing.

Methods

This study reviews the following recent scientific advances applying ACO to ECG analysis:

Gao et al. (2023)[1] introduced a self-adjusting ant colony clustering algorithm with a correction mechanism, achieving high robustness and accuracy in arrhythmia classification using the MIT-BIH dataset.

Korürek & Nizam (2010)[2] applied ACO combined with Principal Component Analysis (PCA) and Discrete Wavelet Transform (DWT) for feature selection and dimensionality reduction, improving classification performance over neural networks and linear discriminant analysis.

Cheng et al. (2016)[3] used population-based ACO to reconstruct ECG signals, optimizing signal quality and reducing noise through adaptive parameter tuning.

Results

The self-adjusting ACO model proposed by Gao et al. achieved 99% classification accuracy, outperforming conventional clustering methods. ACO combined with other models allowed for efficient classification of different arrhythmia types with improved sensitivity and specificity.

Conclusions

Ant Colony Optimization algorithms provide a resource-efficient approach to ECG signal analysis, with proven accuracy in detecting heart rhythm abnormalities. Their bioinspired adaptability makes them promising candidates for implementation in real-life medical scenarios such as portable cardiac monitoring systems, especially in resource-limited healthcare settings.

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sciforum-142349: Learning from Nature: Neural Networks for Gene Expression Modelling and Intelligent Built Environments

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Natural systems display extraordinary capacities for learning, adaptation, and environmental responsiveness, capabilities that have inspired the use of artificial neural networks (ANNs) across diverse scientific and engineering domains. Leveraging the biomimetic paradigm, our work explores how ANNs, originally inspired by biological neural processes, are increasingly employed to model gene expression in molecular biology and to develop intelligent, behaviour-responsive built environments. We conducted a comparative study of recent ANN-based approaches in systems biology, particularly in modelling gene regulatory networks, transcriptional dynamics, and epigenetic modulation, and architectural systems, including adaptive lighting, smart HVAC control, and occupant-driven space optimization. By examining the underlying data flows, feedback mechanisms, and functional architectures, we identified significant conceptual and computational parallels between these domains. Our findings reveal that, in both cases, ANNs serve as effective tools for capturing non-linear relationships, learning from high-dimensional input data, and enabling system-level adaptability. In biological systems, deep learning models accurately predict gene expression patterns from genomic features, while in architecture, recurrent reinforcement learning frameworks enable buildings to anticipate and respond to environmental and user stimuli in real-time. These insights accentuate the utility of ANNs not merely as analytical tools but as design frameworks for creating responsive, learning-enabled systems. We conclude that viewing gene networks and built environments through a unified lens of adaptive intelligence opens new frontiers for cross-disciplinary innovation in biomimetics, where principles of learning and responsiveness evolve seamlessly from genomes to geometry.

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sciforum-133591: Neuromorphic Generative Design: Brain-Inspired Computing Workflows for Self-Adaptive Building Façades

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Introduction

Building envelopes that learn from their environment could transform energy performance, yet conventional rule-based controllers cannot cope with the non-linear, multi-objective nature of façade behaviour. Neuromorphic computing—hardware that reproduces spike-based brain signalling—offers ultra-low-power, real-time inference. This study presents the first closed-loop workflow in which a spiking neural network (SNN) continuously generates and retrains timber-CLT shading morphologies in response to live sensor streams.

Methods

A three-layer SNN comprising 512 leaky-integrate-and-fire neurons was synthesised on a 28 nm field-programmable gate array (FPGA). Photometric, surface-temperature, and occupancy data (1 Hz) from a living-lab office in Lusaka were latency-encoded into spike trains. Network outputs drove a Grasshopper script that reconfigured 240 modular louvred panels; performance feedback—daylight autonomy, glare probability, and predicted mean vote—was returned via EnergyPlus-Radiance co-simulation within a 10 s control horizon. A proportional–integral–derivative (PID) façade served as a benchmark.

Results

After a four-day online-learning phase, the neuromorphic façade reduced annual cooling loads by 35 %, heating by 9 %, and electric-lighting energy by 27 % versus the static baseline, while maintaining 95 % of occupied hours within ASHRAE-55 comfort limits. Decision latency averaged 7 ms and FPGA power draw was only 2.3 W—an 86 % saving over a GPU-based SNN. Actuator travel distance fell by 42 % compared with the PID system, indicating longer mechanical life. A cradle-to-gate life-cycle assessment revealed a 12 % reduction in embodied carbon owing to material right-sizing enabled by the adaptive logic.

Conclusions

Brain-inspired generative design allows building skins to self-optimize luminous, thermal, and energy variables with negligible computational overhead. Coupling neuromorphic hardware with parametric timber components charts a scalable pathway toward self-learning, net-zero-ready façades across diverse climates.

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sciforum-133808: Phototropic-Inspired Neural Growth Algorithms for Adaptive Timber Canopies

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Introduction

Timber canopies that adaptively track daylight can enhance occupant comfort and reduce energy loads; yet, conventional parametric models lack real-time environmental responsiveness. Drawing on phototropism—the growth of plants toward light—this study introduces a neural growth algorithm (NGA) that emulates plant-like directional adaptation to steer parametric canopy geometries in timber architecture. By coupling a spiking neural network to environmental sensors, the system continuously refines panel orientations and supports geometries to balance luminous exposure and structural efficiency.

Methods

An NGA was implemented in Grasshopper using Python and the Elefront plugin. Light intensity data from a grid of photosensors served as input spike trains for a multi-layer spiking neural network, the synaptic weights of which were adapted via a spike-timing–dependent plasticity rule calibrated to phototropic response curves of *Helianthus annuus*. Each network output triggered geometric transformations of an NURBS-based timber canopy mesh, adjusting panel tilt and curvature. Structural performance was evaluated in Karamba3D through modal and deflection analyses under uniform snow and wind loads. Optimization objectives—maximizing the annual daylight factor (ADF) while limiting maximum deflection to L/360—were encoded as reward signals for the NGA. A baseline static canopy and a gradient-based parametric model (Nelder–Mead model) provided comparative benchmarks.

Results

Over a simulated six-month period in Lusaka's climate data, the phototropic NGA canopy achieved a 28 % increase in average ADF (from 1.9 % to 2.4 %) and a 17 % reduction in peak deflection compared with the static design. Relative to the gradient-based model, the NGA delivered similar daylight gains (+3 % ADF) but reduced material volume by 12 % through adaptive node pruning. Convergence of the NGA occurred within 120 iterations compared to 350 iterations for the Nelder–Mead model. Real-time adaptation trials demonstrated sub-10-second reconfiguration cycles, enabling near-instantaneous responses to shifting solar angles.

Conclusions

Phototropic-inspired neural growth algorithms offer a compelling bioinspired route for self-adaptive timber canopies, seamlessly integrating environmental sensing with parametric form-finding. The NGA not only improves luminous and structural performance but also streamlines material usage and computation time. Future work will explore integration with mechanoresponsive joints and field validation in full-scale prototypes.

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Session 3. Bioinspired Materials—Structures, Surfaces and Interfaces

sciforum-141419: Anolis carolinensis exhibits background-dependent, spectrally refined camouflage: chromatic shift dynamic principles and biomimetic potential

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In this study, the green anole (*Anolis carolinensis*), which can rapidly change body color, was selected to explore how environmental color drives adaptive color change in different backgrounds. Individuals were exposed to four uniform chromatic substrates designed to span ecologically relevant and irrelevant background colors. The achromatic contrast, chromatic contrast, overlap, reflectance (360–760 nm), and temporal dynamics of color change were quantified. Image analysis revealed that against backgrounds resembling the species' native habitats (i.e., green and black), lizards shifted their dorsal coloration toward the substrate, significantly decreasing both achromatic and chromatic contrasts while increasing overlap. Conversely, against the ecologically alien red background, no statistically significant chromatic adjustment occurred, and background-matching indices remained unchanged. The time required for color change was likewise background-dependent, with the fastest shifts observed against dark-green and the slowest against black. Furthermore, there was no significant difference in colorimetric or temporal parameters between males and females. Moreover, reflectance analyses revealed that, within the 360–760 nm waveband, the stabilized dorsal reflectance decreased significantly by 12–28 % relative to baseline; nevertheless, stabilized reflectance values remained markedly higher against red and dark-green backgrounds than light-green and black ones, with males consistently exhibiting lower mean reflectance than females. These findings demonstrate that *A. carolinensis* employs a dynamic, spectrally fine-tuned background-contingent strategy for maximizing fitness through optimized concealment. The systematic investigation of how the body color of *A. carolinensis* responds to backgrounds not only paves the way for elucidating the underlying physiological control mechanisms, but also provides a biological prototype for the design and fabrication of actively color-changing biomimetic camouflage materials.

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sciforum-127688: Biomimetic Scaffold Design for Retinal Tissue Engineering: A Novel Approach to Treat Retinal Degenerative Diseases

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Retinal degenerative diseases, such as age-related macular degeneration, are significant causes of permanent vision loss. Recent advancements in tissue engineering have shown promise in developing biomaterial scaffolds to support the growth and integration of retinal cells. This study focuses on designing and developing a novel biomaterial scaffold for retinal tissue engineering and conducting in vitro biomechanical studies to assess its efficacy. The biomaterial scaffold is designed to mimic the extracellular matrix (ECM) of the retina, providing a biocompatible and non-immunogenic environment for the growth of retinal cells. The scaffold is fabricated using a combination of natural and synthetic polymers, ensuring mechanical robustness and high permeability for nutrient exchange. The scaffold's topographical properties and micro/nano-patterned structures are engineered to facilitate the delivery of stem and progenitor cell populations into the sub-retinal space. In vitro, biomechanical studies evaluate the scaffold's performance in supporting cell growth and differentiation. The studies assess the scaffold's ability to maintain cell viability, promote cell adhesion, and facilitate the formation of functional retinal tissue. The results of these studies are expected to provide valuable insights into the potential of the biomaterial scaffold for retinal tissue engineering and its potential applications in treating retinal degenerative diseases. The development of this biomaterial scaffold and the in vitro biomechanical study methods employed in this research aim at advancing the field of ocular tissue engineering and contributing to the development of effective treatments for retinal degenerative diseases. The findings of this study have significant implications for the future of retinal tissue engineering and the potential to restore vision in individuals affected by these debilitating conditions.

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sciforum-138635: Electromechanical Memory in Lipid Bilayers: A Bioinspired Platform for Tunable Biointerfaces

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While biological memory is conventionally attributed to protein-based networks, growing evidence reveals that lipid bilayers themselves can exhibit memory-like behavior rooted in their electromechanical and structural complexity. Drawing from recent studies on long-term potentiation (LTP), memcapacitance, and supramolecular organization in model and native neuronal membranes, we outline a bioinspired framework in which lipid membranes function as adaptive dipolar media capable of encoding and retaining past stimuli. Composed of amphiphilic molecules with polar headgroups, these bilayers support collective dipolar fluctuations that are modulated by electric fields, hydration levels, and ionic composition. Experimental observations demonstrate persistent, stimulus-dependent shifts in membrane capacitance. Notably, such effects are observed even in the absence of proteins, suggesting that the lipid matrix itself possesses intrinsic memory capabilities. We explore the physical basis of this phenomenon through a combination of patch-clamp electrophysiology, molecular dynamics simulations, and X-ray and neutron scattering. Together, these results position lipid membranes as soft, tunable, and energy-efficient memory substrates, offering foundational principles for the design of neuromorphic materials and expanding the scope of biological information processing beyond traditional protein-centric models.

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sciforum-127871: Comparison between different auxetic geometries for mimicking tendons' mechanical properties

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Tendons are biological structures that connect muscles to bones and are fundamental in transmitting the load generated by the muscles to the bones to achieve body motion. Due to injuries and ageing, tendon diseases represent a major clinical challenge. Natural healing of the tendons is slow, responds poorly to treatment, and often requires invasive surgical procedures followed by long-term rehabilitation. Furthermore, full restoration of the original function of the tendon is almost impossible to achieve.

Recently, it has been demonstrated that tendons show auxetic behaviour. An auxetic material is one that exhibits a negative Poisson's ratio. While normal materials shrink in the perpendicular direction when stretched, an auxetic material enlarges in that direction. Similarly, during compression, instead of expanding orthogonally to the load, it collapses in all directions. Different auxetic geometries exhibit this behaviour through various mechanisms.

In this work, we propose mimicking tendon mechanics using auxetic 3D metamaterials. A finite element analysis (FEA) will be used to simulate the mechanical response of various auxetic geometries under tensile and compressive loading, focusing on parameters such as the elastic modulus, stress distribution, and Poisson's ratio. Simulated results will be compared to the mechanical behaviour of native tendons reported in the literature to evaluate their biomechanical fidelity. Polylactic acid (PLA) is selected as the base material due to its biocompatibility, ease of 3D printing, and suitability for short-term applications, although its long-term load-bearing capacity may be limited. Due to these limitations, we decided to also investigate polycaprolactone (PCL) due to its capability to sustain large deformations without showing plastic deformation and ultra-high-molecular-weight polyethylene (UHMWPE), which is a well-known biomaterial widely used in the prosthesis field for its durability and mechanical properties.

The findings of this study may support the development of tendon-mimetic scaffolds for tissue engineering and drug screening. By accurately replicating tendon behaviour, such models could reduce the reliance on animal testing and contribute to more physiologically relevant platforms for studying tendon-related diseases.

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sciforum-141440: Cellular Solids And Their Modeling Approach: Review

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Cellular solids, encompassing both naturally occurring and synthetically engineered foams, exhibit remarkable mechanical properties such as high strength-to-weight ratios, energy absorption capabilities, and tunable stiffness. These characteristics make them indispensable in a wide range of engineering and biomedical applications, including lightweight structural components, impact protection systems, and bone tissue scaffolds. To fully leverage the potential of cellular solids, accurate modeling of their mechanical behavior is essential for both predictive analysis and performance optimization. This study presents a comprehensive comparison of four primary modeling approaches commonly employed to simulate cellular solids: the Unit Cell Method, Tessellation-Based Foam Model, Phenomenological Foam Model, and CT Scan-Based Approach. Each method offers distinct advantages and trade-offs in terms of accuracy, computational efficiency, and applicability. The Unit Cell Method represents the cellular structure using idealized, repeating geometric units such as cubes, tetrakaidecahedra, or other polyhedral shapes. While this approach significantly reduces computational cost and is effective for periodic, regular structures, it falls short in capturing the variability and irregularities found in real-world foams. To address these limitations, the Tessellation-Based Foam Model introduces more realistic representations by using random or quasi-random geometries generated through techniques like Voronoi tessellation. This approach offers improved fidelity in simulating the mechanical response of disordered foams, making it particularly suitable for mimicking natural cellular structures. The Phenomenological Foam Model abstracts the microstructure entirely, instead relying on empirically derived constitutive laws to describe the macroscopic behavior of foams. Although this method is well-suited for large-scale simulations and is computationally efficient, it lacks the capacity to capture microstructural effects and localized phenomena. Finally, the CT Scan-Based Approach leverages high-resolution imaging techniques to reconstruct the actual internal architecture of cellular solids. This method enables the creation of highly detailed finite element models that can faithfully reproduce the material's response under various loading conditions. While offering the highest accuracy, this approach is computationally intensive and dependent on the quality of scan data. By evaluating the strengths and limitations of each modeling strategy, this study aims to guide the selection of appropriate methods for different application scenarios, balancing realism, efficiency, and scalability in the modeling of cellular solids.

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sciforum-133536: What do *Physarum* cosmoldogists think about how nearby galaxies are connected?

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While it is established that galaxies neighboring each other in the Universe are generally connected by concentrations of matter called filaments, individual filaments are often practically impossible to observe. In the Local Sheet, an unusually flat structure that is the Milky Way's home, it is largely unknown which galaxies are connected to each other by these strands. Computer algorithms inspired by *Physarum* slime mold have been developed in the last few years to find how galaxies are connected in 3D maps from surveys of the sky, and these are among the physically meaningful methods to do so. But to our knowledge, biological experiments of *Physarum* itself have not previously been used for this purpose, and we will discuss ours. The Local Sheet is ideal for this: it is particularly meaningful, as our home, and also happens to be convenient, since it is essentially a 2D arrangement. It fits nicely in a standard petri dish, if the dozen or so large galaxies are represented by the oat flakes that *Physarum* gravitates toward. We will characterize the opinion of many experiments about the connectivity of galaxies around us, each one a little ‘cosmoldogist,’ taking due note of the variance among their opinions. Each cosmoldogist builds an efficient structure, but how close is each to optimal? And is ‘optimal’ even clearly defined in this context?

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sciforum-130140: A Basic Framework for Bioinspired Design and Optimization of a Bone-Integrated Prosthesis for Equines

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Horses are frequently exposed to the risk of injuries in daily activities or sports, some requiring special medical intervention or even surgery. Complex or severe injuries, such as comminuted fractures or suspensory ligament ruptures, often result in long-term complications or euthanasia due to insufficient rehabilitation options. This study explores a bioinspired engineering approach to equine prosthetics, investigating the feasibility of a structurally refined and functionally effective alternative to conventional socket-based solutions.

Current prosthetic systems, which rely on soft-tissue socket interfaces, are associated with limitations such as delayed post-operative usability, unstable load transmission, and the risk of pressure-induced necrosis or skin damage. To address these multifaceted challenges, this research applies a biomimetic design strategy by developing a conceptual bone-anchored prosthesis specifically tailored to the equine cannon bone.

The core objective of this study is the development of a semi-automated digital workflow for the design and biomechanical optimization of 3D-printed bone-integrated prosthetic systems. The applied methodology includes anatomical and physiological parameter integration, analysis of biomechanical loading scenarios common in equine locomotion, and the derivation of design constraints from biological principles. Through Finite Element Analysis, the prosthetic concepts are assessed under varying and realistic dynamic conditions to explore functional robustness and structural integrity.

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sciforum-128407: A novel approach to the creation of biomimetic materials for accelerated wound healing based on modified biopolymers

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The creation of innovative materials for accelerated wound healing based on biomimetic systems and biopolymers is an urgent task. Even knowing the rates and stages of skin wound healing, scientists face such problems as prolonged antimicrobial effects, the removal of cellular debris from the wound, the timely application of protein healing activators, and controlled bioresorption of the healing layer. In this paper, we propose an approach to solving the complex problem of accelerated wound healing using biomimetic material obtained by electrospinning followed by modification with protein molecules.

We obtained electrospun biomimetic material based on polyester of natural origin, poly-3-hudroxybutyrate (PHB), modified with hemin (Hmi) and fibrinogen (Fbg). The highly developed bioinspired structure of the material made it possible to control the rate of degradation of the polymer matrix and the release of the antimicrobial component (Hmi). Fbg as the wound healing protein activator provided accelerated wound closure by 35% on the 3rd day compared to the control (gauze and pure PHB), where the closure was 2% and 1%, respectively. At the same time, the degradation of the entire material exactly coincided in time with the rate of wound closure due to the controlled surface density. The paper presents histological studies demonstrating the high potential of the proposed materials and the developed approach. In addition, the structural, chemical, physical, and biological aspects that played a key role in successful accelerated wound closure have been investigated.

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sciforum-118732: An electrochemical approach to the realization of OECTs: a polypyrrole case study

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Organic electrochemical transistors (OECTs) are organic-based devices with interesting electronic properties such as an electron/ion transduction capability, which is essential in various applications. The scientific community is showing great interest in this type of device, exploiting their properties and studying the effect of varying preparation protocols on their performance. OECTs are typically designed starting from commercial PEDOT:PSS dispersions, and their fabrication involves multi-step photolithographic methods. However, several groups are developing alternative methodologies and protocols and different conductive polymers for device realization. Here, we report a facile, reliable, and mask-less electrochemical approach to the realization of polypyrrole (PPy)-based OECTs. Our strategy ensures the realization of conductive channels made of PPy with controlled properties while maintaining low-cost and low-waste fabrication. The results are supported by electronic characterization combined with a deep electrochemical analysis, including cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) techniques. Furthermore, the molecular structural features of the produced materials are evaluated by means of Raman spectroscopy analyses. All of these characterizations allow for the optimization of the synthesis protocols for channel formation and ensure the fabrication of a well-performing OECT with a low voltage range (1V), good transconductance (g_m = 0.26 mS), and excellent stability for pulse stimulation. These outcomes convincingly demonstrate that the proposed electrochemical approach is a simple yet effective way to exploit PPy in OECT applications [1].

[1] Carcione R. et al. "One-Pot and Mask-Less Realization Approach for Polypyrrole−Polydopamine-Based Organic Electrochemical Transistors", *ACS Applied Electronic Materials* https://doi.org/10.1021/acsaelm.5c00124

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sciforum-130365: Bioactive wound-healing hydrogel porphyrin-containing systems based on polycation-stabilized alginates

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Sodium alginate (SA)-based hydrogels are widely used as a base for wound-healing coatings due to their unique physicochemical and rheological properties. The targeted modification of SA hydrogel by co-integration with polycations, particularly PAMAM dendrimers, allows for formulating a platform for the immobilization of bioactive agents, followed by their subsequent controlled release. The integration of porphyrins that mimic the superoxide dismutase (SOD mimetics) will suppress oxidative stress in the area of tissue damage and prevent the formation of fibrous tissue. Thus, obtaining a polycation-stabilized SA hydrogel with immobilized SOD mimetics is a promising task in the field of regenerative medicine.

The materials used in the study were SA (Mw = 1600 kDa), third- and fourth-generation PAMAM dendrimers (G3 and G4), and porphyrin with the composition $C_{44}H_{28}ClMnN_4$. During the first stage of the work, we assessed the concentration of SA responsible for the formation of an elastic gel. Based on the data obtained by potentiometric titration, we revealed the degree of PAMAM binding to SA to be 98% (G3) and 85.53% (G4) at pH 7.4. Next, we studied the PAMAM-SA complex using FTIR and UV spectrophotometry. During the second stage of the work, the possibility of incorporating porphyrin into PAMAM (G3 and G4) was studied. We found that there are on average six porphyrin molecules per dendrimer macromolecule at a concentration of 10^{-3} mg/ml. We conducted a series of studies on cytocompatibility of the porphyrin-containing hydrogel systems based on the developed polycation-stabilized alginates.

The results confirmed the possibility of formulating a biocompatible porphyrin-containing system based on polycation-stabilized sodium alginate for accelerated regeneration of skin and mucous membranes.

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sciforum-122614: Bioinspired Collagen–rGO Hydrogels with Enhanced Interfacial and Functional Properties for Wound Healing Applications

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Nature-inspired strategies have become pivotal in the design of advanced biomaterials. Collagen, the main structural protein of the extracellular matrix, offers a biomimetic scaffold for tissue engineering, while reduced graphene oxide (rGO) contributes exceptional physicochemical and electrical features. In this work, we report the synthesis and characterization of bioinspired hydrogels based on type I collagen enzymatically cross-linked with horseradish peroxidase (HRP) and functionalized with dopamine-reduced rGO (rGO@PDA). This approach enables the formation of 3D porous architectures that emulate the structure and conductivity of native skin tissue. The presence of rGO enhanced the surface charge (−79 mV), electrical conductivity (up to 39.6 mS/m), and mechanical strength of the hydrogels, while also improving their resistance to enzymatic degradation and modulating pH-responsive swelling. Interfacial bonding between collagen and rGO was confirmed by FTIR, XRD, and XPS, supporting the formation of a stable nanocomposite matrix. In vitro biological evaluations demonstrated excellent biocompatibility and significantly accelerated fibroblast migration. The COL/rGO100 formulation achieved 84.5% wound closure after 48 h, surpassing control groups. The combination of structural mimicry, antioxidant performance, and conductivity makes these hydrogels promising candidates for next-generation bioinspired wound dressings. These results highlight the potential of rGO-integrated collagen systems in replicating and enhancing key interfacial and functional properties of natural tissues, offering a platform for future developments in regenerative medicine and soft bioelectronics.

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sciforum-131871: Bioinspired composite: influence on electrical conductivity of carbon nanotubes with different hydrodynamic radii in photoresist

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Introduction

Based on carbon nanotubes, neuroimplants are being developed whose task is to faciliatate communication between neurons through a damaged area of tissue, as well as blocking pain signals. In such systems, feedback between the stimulated area and the neurostimulator is important. The design of such implants is being developed, taking into account the characteristics of the biological system.

The bioinspired composite includes single-walled carbon nanotubes (SWCNTs), bovine serum albumin (BSA), collagen, chitosan, and Eosin Y. To achieve the required electrical conductivity with minimal use of nanotubes, a study was conducted to determine the effect of the size of their bundles.

Methods

When developing artificial synapses, the use of SWCNTs in combination with biopolymers is promising. The change in electrical conductivity of the composite manufactured by photolithography, with a content of 0.03 wt. % SWCNTs in the photoresist, was estimated. As a result of ultrasonic treatment, variants of SWCNT size distributions in bundles were obtained, which were characterized by the dynamic light scattering (DLS) method.

Results

Depending on the amounts of bundles of SWCNTs with different hydrodynamic radii, the values of relative specific conductivity of the composite were obtained. The specific indicators were 1 (0.35 μm, 73%), 1.7 (28 μm, 99%) and 3.7 (95 μm, 97%). Conductivity was normalized relatively to the minimum obtained value.

Conclusions

With an increase in the size of bundles of nanotubes in a composite manufactured by photolithography, an increase in specific conductivity by 3.7 times is achieved. The structure of such a neurointerface is based on the principles of the original biological system, which contributes to its bio-inspired design and functionality.

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sciforum-128725: Bioinspired Sn-Substituted Hydroxyapatite for Dental Desensitization: Structural Insights and Synthesis Optimization

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Introduction

Dentin hypersensitivity affects 15–30% of adults due to exposed dentinal tubules reacting to thermal or chemical stimuli. Conventional SnF_2-based treatments offer short-term relief but suffer due to the chemical instability of Sn^{2+} ions in the oral environment, poor taste, and limited integration with tooth structures. Hydroxyapatite (HAp), the primary mineral of enamel and dentin, provides a biocompatible and bioinspired scaffold for ion substitution. Incorporating Sn^{2+} into HAp could combine remineralization with long-lasting desensitization. However, Sn^{2+} is notoriously unstable—it oxidizes easily and hydrolyzes in aqueous environments. This study addresses the challenge of stabilizing Sn^{2+} during synthesis to ensure its incorporation into the HAp lattice, enhancing structural similarity to native enamel.

Methods

Sn-substituted HAp ($Ca_9Sn(PO_4)_6(OH)_2$) was synthesized via co-precipitation using $Ca(NO_3)_2{\bullet}4H_2O$, $SnCl_2$, and $(NH_4)_2HPO_4$. Two solvent systems for $SnCl_2$ were compared: ethanol (low polarity, limits Sn^{2+} hydrolysis and oxidation) and 0.01M HCl (aqueous, stabilizes Sn^{2+} via acidification). Precipitation was induced at pH 7 using NaOH, followed by annealing at 500–900°C. Structural properties were analyzed by X-ray diffraction (XRD).

Results

Ethanol-based synthesis yielded sharper XRD peaks (e.g., intensity 179 vs. 125), indicating higher crystallinity and reduced structural defects. Peak shifts confirmed Sn incorporation: rightward shifts (e.g., 31.7° → 31.9°) suggested Sn^{2+} substitution for Ca^{2+}, while leftward shifts (e.g., 25.9° → 25.7°) implied lattice strain from Sn^{2+} ions. Below 600°C, crystallinity improved with annealing; above 800°C, secondary phases (e.g., $Ca_2P_2O_7$ and SnO_2) appeared, suggesting partial decomposition. Ethanol minimized Sn oxidation and enabled uniform Sn^{2+} incorporation. Acidic media resulted in broader peaks, likely due to point defects and cation vacancies, which could be beneficial for bioactivity but less ideal for structural integration.

Conclusions

Sn-HAp synthesized in ethanol and annealed at 600°C yields a structurally stable, enamel-like material with Sn^{2+} effectively integrated into the HAp lattice. This bioinspired material offers promising long-term desensitizing performance. Ethanol-based synthesis is preferred for applications requiring high crystallinity and biostructural fidelity. Acidic synthesis, while less structurally precise, may offer potential for bioactive or resorbable materials. Future research will focus on optimizing Sn content and evaluating in vitro bioactivity.

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sciforum-130659: Biomimetics and sustainability: rethinking nature-inspired design

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Biomimetics is often celebrated as a pathway to sustainability, yet the mere imitation of nature does not inherently lead to environmentally responsible outcomes. As authors of the article "Engineered Materials: Bioinspired 'Good Enough' versus Maximised Performance" (Adv. Funct. Mater. 2023), we challenge the widespread assumption that biomimetic design inherently leads to sustainable outcomes.

For example, mimicking the strength of nacre or the hydrophobicity of lotus leaves has often resulted in synthetic composites or coatings that are difficult to recycle or require toxic solvents. These practices illustrate that form alone is insufficient; the materials and methods of fabrication matter just as much.

While functionally impressive, this talk will show how bioinspired materials frequently rely on energy-intensive or non-recyclable materials and processes that undermine their ecological value.

By contrasting these approaches with a good enough design philosophy that balances performance with material and process sustainability, we advocate for a shift in focus from maximising performance to optimising environmental impact.

This presentation calls on biomimetic practitioners to adopt holistic evaluation methods, including life cycle analysis, and to prioritise sustainability as a core design criterion. Integrating these assessments early in the design process helps avoid unintended consequences and aligns biomimetic innovation with global sustainability goals and regulatory frameworks.

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sciforum-142038: Characteristics of Iridophore Crystals in *Anolis carolinensis*

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In recent years, progress has been made in the research on the dynamic optical regulation and multi-scenario adaptability of biomimetic materials. Chameleons or lizards are commonly used biomimetic objects for color-changing or thermostatic materials. Previous studies primarily focused on analyzing the color characteristics of lizards, such as dynamic color changes and pigment distribution in response to various factors (e.g., temperature and background). However, the structure of purine crystals within iridophore cells and their specific role in body color modulation remain poorly understood. In this study, *Anolis carolinensis*—a lizard capable of rapid body color changes—was selected as the experimental subject. First, reflectance measurements (300–700 nm) were conducted on different body regions (head and dorsum). Subsequently, paraffin sectioning, transmission electron microscopy (TEM) and scanning electron microscopy (SEM) were employed to quantitatively analyze purine crystals in the skin of these regions. Reflectance data revealed significant differences between the head and dorsum, with the head exhibiting significantly lower reflectance than the dorsum. Histological analysis using paraffin sections revealed a distinct cellular organization in lizard skin: xanthophore clusters were observed in the superficial layer, with iridophore aggregations directly beneath them, and melanophores positioned in the deepest stratum. When the skin color changes from green to brown, the melanin can migrate to the area above xanthophores, resulting in a brown skin coloration. TEM analysis showed that the purine clusters in the iris layer exhibited a relatively uniform but regionally concentrated arrangement, forming a unique ultrastructural pattern in the lizard skin. Further examination of crystals extracted from iris cells using SEM revealed lumpy or short columnar structures that were often stacked on top of each other, with facet diameters of 172.46 ± 29.67 nm and particle sizes of 95.30 ± 13.13 nm. Significant differences in crystal size were observed between the head and dorsum, with the dorsolateral lens being thicker and the facet diameter larger than the crystals of the head. These findings suggest that differences in crystal structure and size in different parts of *A. carolinensis* affect the reflectivity of the skin and thus cause differences in reflectivity. This study provides a scientific basis for further understanding the mechanism of color-changing in ectotherms, and lays a theoretical foundation for the design and manufacture of functional materials such as dynamic color-changing or high-sensitivity optical sensing.

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sciforum-138223: Development, Evaluation, and Validation of a Realistic Simulator for the Human Left Ventricle

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Introduction

Mock circulation systems are widely used for preclinical testing of cardiovascular implants. Existing setups are driven by sophisticated hardware and complex control algorithms, which increase costs, whereas animal models raise ethical concerns. Computational simulations can address some limitations but may be oversimplified or computationally expensive. We present a low-cost and realistic left ventricular (LV) simulator designed for the efficient evaluation of physiological scenarios to overcome the challenges mentioned above.

Methods

Interpretive Structural Modelling (ISM) was utilised to compare three different beating LV simulator design approaches (pneumatic artificial muscle, flexible band, and artificial muscle actuation) and analyse the interaction of factors and their effects on the performance of the LV simulator. ISM guided the selection of pneumatic artificial muscles and latex rubber as the optimal actuation method and material for replicating LV motion. Finite element simulations were employed to evaluate an LV model, similar in size to the native LV, made of latex rubber and driven by pneumatic artificial muscles. A prototype of the LV model was also built to validate the numerical simulations.

Results

Numerical simulations predicted an apex twist of 17 degrees and long-axis shortening of 11 mm. Experiments at 50, 60, and 70 bpm demonstrated the simulator's ability to generate flow rates up to 2.27 L/min. Mechanical performance matched with the native LV behaviour and numerical results, with apex twisting between 18 degrees and 21 degrees, and an apex shortening ranging from 5 mm to 11 mm.

Conclusions

Twist angles and long-axis shortening show that it is capable of functioning like a native left ventricle. The simulator's geometry, including basal diameter and long-axis length, matches native human LV anatomy. Therefore, the developed LV simulator combines anatomical fidelity and cardio-mechanical performance in a relatively simple and cost-effective configuration, making it a promising tool as a test setup.

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sciforum-136677: Developmental Trajectory of Jumping Ability in *Lycorma delicatula*

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The biomechanics of insect jumping has long been a focal point in entomological research, with prior investigations predominantly characterizing the locomotive performance of adult insects. However, the developmental trajectory of leaping capabilities across ontogenetic stages remains poorly understood, particularly for species exhibiting significant morphological and behavioral plasticity. This study addresses this knowledge gap by systematically analyzing the developmental progression of jumping ability in *Lycorma delicatula* (Hemiptera: Fulgoridae), an invasive phytophagous planthopper with remarkable adaptive locomotion strategies. Through a combination of high-speed videography, micro-computed tomography (μCT) scanning, and kinematic analysis, we quantitatively compared the morphological structures and biomechanical parameters of both nymphal and adult stages. Our results revealed a 3-fold increase in hind femur length from fifth-instar nymphs to adults, accompanied by a 4.2-fold enhancement in takeoff velocity. Notably, while nymphs exhibited a "short-distance burst" jumping pattern with limited aerial control, adults demonstrated a more sophisticated ballistic trajectory with extended flight duration and precise landing orientation. Morphometric analysis further identified allometric growth in the trochanter–femur–tibia linkage system, with the protraction–retraction angle expanding from 32° in nymphs to 58° in adults. These findings suggest that the developmental refinement of jumping ability in *L. delicatula* follows a two-phase adaptation model: initial survival-oriented short-range jumps in early instars transition to energy-efficient, long-distance leaps in mature adults. This study provides novel insights into the ontogenetic biomechanical evolution of insect locomotion, with implications for understanding both developmental plasticity and ecological invasiveness in hemipteran pests. The phase-specific optimization of jumping mechanisms, particularly the synergistic relationship between morphological scaling and kinematic efficiency, offers valuable biomimetic principles for designing bio-inspired micro-robotic systems.

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sciforum-131854: Encapsulated bacteria-supported palladium nanoparticles in sol–gel material as core–shell catalyst for Mizoroki–Heck reaction.

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In modern chemistry, palladium nanoparticles supported on various supports occupy leading positions among catalysts of organic synthesis. Catalysts based on palladium are widely used in various technological processes due to their high activity and stability. Traditionally, silica and alumina, as well as carbon in various modifications, are used as supports. These materials show stability, inertness and a high surface area as metal nanoparticle supports. However, modern research is aimed at finding alternative supports and ways to improve the characteristics of catalysts. In recent years, special attention has been paid to so-called "living" supports, which are represented by plants and microorganisms. This approach is not only environmentally friendly but also opens up new horizons for the preparation of highly efficient catalytic systems.

In the present work, a method for the synthesis of a core–shell palladium catalyst using microbial cells and sol–gel technology was revealed. The core component comprises the bacterial cells of Paracoccus Yeei with distributed palladium nanoparticles on them. The shell component is an organosilicon matrix that ensures the stability of the structure. The conducted studies showed that bacterial cells are completely covered with organosilicate material, while the formation of the outer shell does not have a significant impact on the size and distribution of palladium nanoparticles. It is important to note that the resulting catalyst demonstrates high activity and selectivity in the Mizoroki–Heck reaction, which opens up broad prospects for its practical application in organic synthesis. The developed catalyst can be scaled up and can became the basis for creating a new family of biohybrid catalysts.

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sciforum-133937: Enhancing Compressive Performance of Gyroid Structures Through Evolutionary Design

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Gyroids are fascinating natural structures belonging to a specific family of structures known as triply periodic minimal surfaces (TPMSs). These surfaces are of significant interest to physical scientists, biologists, and mathematicians due to their unique properties characterized by their local minimum surface area with equal periodicity in all three spatial directions, making them continuous and isotropic. Gyroids specifically can be found in various biological systems like butterfly wing scales, bird feathers, etc., where, depending on the occurrence, the intricate pattern of gyroid structures provides characteristic colors, strength, flexibility and necessary insulation.

Although the mathematical model of the gyroid was developed back in the 1970s, the complexity of the structure hindered its practical applications. However, recent developments in 3D printing technologies and design tools have made it possible to manufacture such geometries with intricate details. This has led to innovative applications in various industries, including aerospace, automotive, and biomedical sectors.

In this work, the objective was to enhance the compressive performance of gyroid structures while maintaining the basic aspect ratio. This was achieved by decomposing the gyroid surface into its constituent surface elements and rebuilding it through edge modification based on evolved curves inspired by biomimicry. Taking inspiration from the growth of a plant's auxins towards light, we established a relationship between form and force. An evolutionary program was used to evaluate optimal curves under such criteria. These curves serve as new edges for the new pseudo-gyroid geometry.

Prototypes with different aspect ratios, cell numbers, wall thickness, and materials were produced by using 3D printing. Under compression, the pseudo-gyroid samples performed significantly better than the standard gyroid shapes for every instance. The results were further validated using finite element models, providing good evidence for further research into the modification of such structures to exploit their full potential.

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sciforum-123239: Fractal Architecture as a Foundational Design Principle in Biomimetic Material Engineering

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Fractal structures are fundamental patterns that repeatedly emerge across biological systems—from alveoli and dendritic trees to vascular networks and neural circuits—supporting highly efficient, resilient, and scalable architectures. Yet, many biomimetic designs mimic biological shapes rather than the structural principles underlying their efficiency. This work proposes a new paradigm in bioinspired engineering by introducing a mathematical framework that reveals function-specific optimal fractal dimensions (e.g., D = 1.7, 2.1, 2.5, 2.9), derived from quadratic performance curves. Each dimension is tailored to a distinct functional goal such as exploration, absorption, circulation, or structural robustness. Unlike heuristic or purely empirical approaches, our model quantifies the fractal design landscape and enables predictive optimization. By mapping dimensionality to system functions, we demonstrate how generalizable design laws can emerge in soft materials, nanostructures, and bio-hybrid interfaces. This framework also offers insights into why fractal architectures naturally evolve in biological systems and how they can be reverse-engineered for high-efficiency human-made systems. The study further connects fractal geometry with multiscale optimization theory and network resilience, drawing from interdisciplinary fields including neuroscience, AI architecture, and materials science. The resulting model provides a modular and scalable blueprint for next-generation biomimetic materials that are energy-efficient, functionally adaptive, and evolutionarily robust. Originating from an undergraduate thesis, this preprint lays the foundation for a broader theoretical framework to unify fractal principles in both natural and artificial systems. It has already been published on ResearchGate with a DOI (10.13140/RG.2.2.29404.91520) and is now submitted as an abstract to further broaden visibility and scholarly feedback. We believe this proposal may stimulate new discussions across bioinspired engineering, network theory, and intelligent material design.

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sciforum-130656: From mussels to muscles: A Bioinspired Film that Contracts in Response to Light

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Poly-catecholamines have received significant attention for their versatile properties and straightforward fabrication methods. In this work, we present the results of investigations conducted on films comprising one such polymer, namely, polydopamine (PDA). The polymer's monomer, dopamine, comprises a benzene ring with two adjacent hydroxyl side groups, called catechol, further connected to an amine group through an ethyl chain. The same groups co-occur in the adhesive proteins found in mussels, possessing a unique ability to stick their bodies to a wide variety of surfaces, including adhesion underwater. In the search for membranes thicker than electropolymerization would normally allow for nonconductive polymers, multiple ≈20 nm thick PDA layers were stacked, utilizing PDA's analogous adhesive qualities. This resulted in samples consisting of 1-4 PDA layers of up to ≈58 nm total thickness. The samples possess great elasticity (characterized by Young Modulus values of 7.3-9.3 GPa), which we assessed utilizing Brillouin Light Scattering (BLS). These results indicated that the stacked PDA films can be effectively treated as a single thick layer. The membranes absorb visible light, similarly to the various photosynthetic pigments found in algae in plants. Red laser light (λ = 660 nm) irradiation measurements resulted in obtaining the extinction coefficient of PDA, whose value was magnitudes larger than that of classical polymers. These exceptional absorptive qualities allow for finely tuned control of the membrane morphology. Applying heat induced by a laser beam causes water desorption from the sample, manifesting as the flattening of the membrane surface, analogous to the contractions of muscle tissue. This process was found to be reversible, with the removal of the stimulus resulting in the spontaneous wrinkling of the surface due to water resorption. The laser light-induced motion investigations lead to the characterization of PDA as a ultra-thin actuator characterized by relaxation times of the order of ≈1-10 ms.

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sciforum-130145: How the cuticle of soil-digging beetles can help us achieve non-stick surfaces for soil tillage tools: a review

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Over the last 25 years, numerous studies on soil-digging animals have been published. Many of them are focused on analyzing the characteristics of the cuticle of soil-digging beetles to find what variables of the topographical pattern lead to non-stickiness, seeking to apply this functional property to soil tillage tools.

The great diversity of soil-dwelling species makes it possible to approach studies from different angles. Over the last several years, our group has been investigating this topic by microscopically observing specimens and cuticle replicates. We are currently focused on analyzing different species of the Scarabidae family. These dung beetles are insects that play a crucial role in the ecosystem, feeding and breeding in the dung of herbivorous animals.

The present paper is a general review of scientific works related to soil anti-adherence through the study of soil-digging beetles. Many questions emerged after reading the prevailing literature on the subject, including the following: What is the best topographical pattern that should be used to enhance the functional property of non-stickiness? Is it possible to find a characteristic pattern common to all species? Will such a pattern depend on the physical properties of the soil where these beetle species live? And, is it more effective to use topographic patterns with protrusions or dimples?

The conclusion of this review is that we are still far from understanding what the best physical conditions of the topographic pattern are to achieve an optimal anti-adhesion function. We are far from finding the optimal pattern, if it even exists.

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sciforum-130282: In Silico Assessment of Natural Biodegradable Polymers for Dermal Drug Delivery Systems

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Biodegradable polymers derived from natural sources are gaining attention as components in dermal drug delivery formulations due to their low toxicity, compatibility with biological systems, and biodegradability. Their physicochemical traits can significantly influence their ability to serve as carriers in topical drug delivery. Hansen's three-dimensional solubility (HSP) concept can be used to preliminarily assess the compatibility of tested polymers as drug carriers and determine their potential for effective drug delivery [1]. In this study, the HSP approach was employed to analyze the suitability of alginate, pectin, dextran, and hyaluronic acid for drug delivery through the skin. All of these polymers are widely used natural polymers known for their non-toxicity, hydrophilicity, and ability to form stable gels, making them attractive for various pharmaceutical and biomedical applications. A sphere with (δd, δp, δh) coordinates is experimentally defined (δd =16.5, δp =12, δh = 7.7, Ro (the radius of interaction sphere) = 6.3), representing the region with the desired polymer characteristics [2]. Compounds located within the defined HSP sphere (RED 1) are considered to have appropriate drug delivery profile. The HSP values for the selected polymers were determined using the HSPiP software (https://www.hansen-solubility.com/). Among the materials tested (hyaluronic acid, alginate, pectin, and dextran), hyaluronic acid exhibited the lowest RED value, suggesting that it is the most promising of the four polymers for dermal drug delivery.

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sciforum-133843: Integration of 3D Bioprinting in Bone Tissue Engineering Using Chitosan Hydrogels: Preliminary Experiments Based on Formulation and Characterization of Three Chitosan Hydrogels

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In bone tissue engineering, chitosan hydrogel has become a promising material for scaffolds due to its biocompatibility and structural and functional similarities with glycosaminoglycans—essential components of the extracellular matrix. One of its key advantages is its ability to promote osteoblastic adhesion, which is crucial for initiating bone regeneration. Additionally, adding phosphate salts to chitosan mixtures serves two purposes: it stops the gel from forming too quickly during preparation—making it easier to handle and inject—and helps mesenchymal stem cells turn into bone-forming cells, which aids in creating bone tissue.

The advent of 3D bioprinting has revolutionized tissue engineering by enabling the fabrication of complex, patient-specific scaffolds with precise control over architecture and cell distribution. Chitosan hydrogels are considered attractive candidates for bioinks in 3D bioprinting due to their favorable biological properties. However, their application is hindered by inherent limitations, i.e., notably slow gelation rates and weak mechanical properties, which compromise the printability and structural integrity of the printed constructs.

In this study, we formulated and characterized three different chitosan-based thermosensitive hydrogels to evaluate their suitability as biomaterial inks for bone tissue engineering applications. The investigation focused on assessing their rheological behavior and mechanical performance—critical factors influencing printability and scaffold stability. Specifically, we determined the gelation time of each hydrogel and assessed their linear equilibrium modulus plateau through frequency sweep tests. Additionally, the compressive strength of the hydrogels was measured to evaluate their structural integrity under mechanical stress. Beyond these mechanical properties, we examined other essential characteristics, including swelling capacity and antibacterial activity, to provide a comprehensive understanding of their functional performance through a comparative analysis.

Our findings aim to inform the development of chitosan-based bioinks with enhanced properties, facilitating their application in 3D bioprinting for bone tissue engineering.

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sciforum-133594: Lotus-Effect Hydrophobic Coatings on Engineered Wood: Toward Self-Cleaning Building Envelopes in Humid Climates

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Introduction

Maintenance of timber façades in humid climates is challenged by biofouling, staining, and moisture-induced degradation. Inspired by the superhydrophobicity of lotus leaves, this study investigates silica-based nano-rough coatings applied to cross-laminated timber (CLT) panels. By replicating hierarchical surface textures, the coating aims to induce self-cleaning behaviour, reduce water uptake, and inhibit fungal colonization without altering timber's visual character.

Methods

A sol–gel process was used to deposit bimodal silica nanoparticles (50–200 nm) onto kiln-dried CLT samples via dip-coating. Surface morphology was characterized by scanning electron microscopy (SEM) and atomic force microscopy (AFM). Static and dynamic water contact angles were measured per ASTM D7334 to assess hydrophobic performance and contact-angle hysteresis. Fungal resistance was tested by exposing coated and uncoated specimens to *Trametes versicolor* in a humidity chamber at 28 °C and 90 % RH for 12 weeks. Optical transmittance and colourimetric shifts were recorded with a spectrophotometer to verify aesthetic neutrality.

Results

Coated surfaces exhibited hierarchical micro- and nano-roughness, achieving an average static contact angle of 159 ° and contact-angle hysteresis below 4 °, compared with 65 ° and 22 ° on uncoated CLT. Simulated rain tests showed >95 % removal of surface particulates on coated panels versus 40 % on controls. After fungal exposure, mass loss in coated samples was 1.2 % (±0.3 %), significantly lower than 7.8 % (±1.1 %) in uncoated specimens (p 0.01). Spectrophotometry indicated ΔE* 1.5, confirming minimal impact on timber appearance.

Conclusions

The lotus-effect coating delivers superhydrophobicity, effective self-cleaning, and substantial fungal resistance while preserving the natural aesthetics of CLT. Its low application complexity and durability under accelerated weathering suggest strong potential for reducing maintenance loads on timber building envelopes in tropical and subtropical regions. Future work will explore field trials and long-term UV-stability to validate lifecycle performance.

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sciforum-130388: Phage-formed liquid crystal fiber biotemplates for material synthesis

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Over the past decade, molecule biologicals have been utilized in the synthesis of diverse materials. One such molecule biological is the M13 bacteriophage, which is exploited to fabricate defined chemical and physical structures. The filamentous virus M13 is a bacterial guest, completely innocuous to human beings. The M13 phage consists of a single DNA in a coat protein, whose major helical protein is called p8 and is 800 nm in length and 6 nm in diameter. The p8 protein has a helical structure and approximately 2700 subunits. [1]. On both tips there are a few distinct proteins (p3, p6, p7 and p9). The protein p8 can undergo modification via genetic engineering or chemical conjugation. It can acquire different functionalities such as the nucleation of different materials.

In this work, we focus on the use of the M13 phage as a platform for the synthesis of noble metal nanoparticles (Au, Ag or Cu) and the formation of liquid crystals at different concentrations. We genetically engineered the amino acid sequence of the protein p8 to understand that a single charge mutation on the capsid affects direct inter-viral interactions. It has also been analyzed whether a single hydrophobic mutation located at the hydrophobic interface that stabilized capsid assembly alters the atomic structure of the phage, mainly affecting inter-subunit interactions and controlling the macroscopic arrays [2]. The introduction of new functional chemical groups, such as thiol groups, is related to the conjugation of noble metal nanoparticles [3].

The M13 phage has the capacity to self-organize into liquid crystal phases depending on the molecular structure of the p8 protein [4], in different concentrations, being nematic (10-20 mg/mL), cholesteric (20-80 mg/mL) and at high concentrations smetic-phase (100 mg/mL) [4]. Furthermore, it can form hierarchically organized rigid and soft platforms. We used different methods to obtain thin films, for example, using the dip coating technique, and, in this way, obtained different liquid crystal phases by modifying parameters such as speed and concentrations.

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sciforum-130373: Preparation and characterization of alginate/hyaluronate hydrogel incorporating zoledronic acid-loaded chitosan microparticles for osteoarthritis therapy

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Osteoarthritis features cartilage degeneration, synovial inflammation, and osteophytes, causing pain, impaired mobility, and reduced quality of life. Key causes include impaired synovial fluid biopolymer synthesis and cartilage degradation. To correct synovial fluid viscoelasticity and prevent joint inflammation, a hydrogel system of sodium alginate (SA) and sodium hyaluronate (NaHA) with zoledronic acid (ZOL) loaded chitosan microparticles (Cs-mPs) offers a promising solution.

For injectable system development, high molecular weight SA, NaHA, and Cs polymers were selected, with ZOL serving as the therapeutic agent. Viscometry determined optimal SA/NaHA concentrations and volumetric ratios prior to hydrogel formation. The hydrogel network was formed via ionic cross-linking with $CaSO_4$.

Subsequently, Cs-Ps were prepared via ionotropic emulsion gelation. Particle characteristics (including size, PDI, and zeta potential) were evaluated by Dynamic Light Scattering (Malvern, UK), confirming parameters essential for ionic binding with ZOL. The microparticles obtained were loaded with ZOL, with a loading capacity of 10% of mPs mass. The loaded particles were then incorporated into the hydrogel network.

At all stages of system development, cytotoxicity and cytocompatibility studies of its components were conducted using a primary human chondrocyte cell line. The obtained data indicate the absence of acute toxicity.

The results confirm the feasibility of obtaining a biocompatible SA/NaHA-based system for subsequent loading with ZOL-containing Cs-mPs and its application as a therapeutic agent for osteoarthritis treatment.

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sciforum-116782: Preparation and Characterization of Kombucha-Derived Bacterial Cellulose for Advanced Antimicrobial Biomaterials

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Wound management materials are highly advanced materials that enhance health outcomes in various settings. The high cost of such materials limits their wide-spread use, particularly among under privileged population. Therefore, developing low-cost biomaterials is crucial to reduce healthcare expenses, expanding access, and improving patient outcomes. Microbial invasion at the site of injury can pose a significant risk of infection, and as the microbes proliferate, they may lead to biofilm formation and impaired wound healing. Thus, significant consideration must be given when designing wound dressings, including features such as high exudate absorption capacity, biocompatibility, biodegradability, and infection resistance. Among various biopolymers, bacterial cellulose (BC), produced by the Gram-negative bacteria *Acetobacter xylinum*, holds its pivotal significance due to its natural nanofibrous structure, mechanically robust nature, purity, and high water retention. Therefore, present study was undertaken to prepare BC pellicle by simple and facile approach of aerobic fermentation in the presence of symbiotic culture of bacteria and yeast (SCOBY). Prepared pellicles were washed to remove adhered bacterial cells and oven dried at 60ºC for 24 h. Various reaction parameters such as time of fermentation, pH, and temperature were optimized for the yield. FTIR studies of pellicle was carried out to confirm the presence of characteristic functional groups. XRD analysis was employed for the assessment of crystallinity whereas, SEM revealed the surface morphology of nanofibrous structure of size range 20-50 nm. Swelling analysis revealed more than 900% water retention capacity of the pellicle. To incorporate antimicrobial properties, BC pellicle was functionalized by adding herbal extract. Zone of inhibition and colony count method was carried out which indicated more than 80% of viable colony reduction against *S. aureus* and *E. coli*. This study implicated that BC can be transformed into a multifunctional sustainable material that combats infection for various healthcare applications.

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sciforum-116934: Simultaneous Targeted Isolation and Controlled release of Circulating Tumor Cells (CTCs) using a photothermal scaffold-embedded microfluidics system

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The isolation of a diverse sample of circulating tumor cells (CTCs) can be achieved either in an active or passive manner. While passive approaches manage cells via channel architectures, intrinsic hydrodynamic forces, and steric hindrances, active methods use external fields like electric, magnetic, acoustic, and optical forces to separate cells. However, processing complex biological materials, such as whole blood with unusual cells, makes separation with a single-module microfluidic device difficult. In recent years, hybrid microfluidic devices with both passive and active components have gained popularity as a method for the label-free enrichment of circulating tumor cells due to their many advantages, such as high sensitivity, high efficiency, and multi-target cell processing. The goal of this study was to create a near-infrared (NIR) light-responsive substrate by combining a thermos-responsive film with microchannels of varying lengths in order to accomplish an extremely efficient targeted capture and biocompatible site-release of CTCs. Pre-synthesized photothermal agent gold nanorods (GNRs) were integrated into biodegradable scaffolds. Later, a nano-film was fixed onto a chip. To improve the capture efficiency of receptors, molecule folic acid (FA) and haluronic acid (HA) targeting cancer cells were respectively adsorbed using a straightforward dipping technique for a GNR film. Temperature-responsive films quickly change their conformation upon NIR irradiation at 37°C or higher, enabling either site-specific release of individual CTCs through NIR-mediated photothermal activation of embedded GNRs, or the bulk recovery of trapped CTCs at a physiological temperature. This hybrid microfluidic NIR-responsive platform not only provides a robust and flexible route toward tailored anticancer therapies, but it also excels in the collection and site-release of CTCs with excellent survivability.

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sciforum-132730: The biosynthesis of palladium nanoparticles by microorganisms and their relationship with biomimetic structures

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The bioproduction of palladium nanoparticles using microorganisms is a promising area of green chemistry, combining environmental safety with high efficiency. Many bacteria can reduce palladium ions (Pd^{2+}) to form palladium metal (Pd^{0}) nanoparticles. This process is often driven by enzymatic activity and/or bacterial surface structures. A key advantage of biosynthesis is the ability to produce highly homogeneous palladium nanoparticles of tightly controlled size, which is critical for catalytic and electrochemical applications. Nanoparticles formed by biogenic pathways often exhibit unique morphological characteristics, including spherical, rod-shaped or core–shell structures. The connection with biomimetic structures is evident based on the fact that biogenically synthesised nanoparticles often replicate the morphology of natural functional materials. Additionally, the principle of 'copying nature' is employed to replicate the catalytic centres of enzymes or cell wall structures. This makes biogenic palladium nanoparticles an interesting subject for developing biomimetic catalysts for organic synthesis. Therefore, the microbiological production of palladium nanoparticles offers a sustainable, environmentally friendly alternative to traditional synthesis methods, reducing toxicity and energy costs. Integrating knowledge from microbiology, materials science, and biomimetics paves the way for creating new functional nanomaterials that are highly efficient and compatible with living systems. In this study, palladium (Pd°) nanoparticles were synthesised using Gram-negative bacteria. As a result of the biosynthesis process, stable nanoparticles with a narrow size distribution were produced. The morphology and size of the resulting palladium nanoparticles were examined using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The particles were found to be located both on the cell wall surface and in the periplasmic space. A model cross-coupling reaction was then performed to evaluate the catalytic activity of the synthesised nanoparticles. The results confirmed the feasibility of using a biogenic palladium catalyst in organic synthesis reactions. This suggests potential for the further development of biogenic palladium-based catalysts for sustainable, environmentally friendly catalysis in organic chemistry.

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sciforum-129583: The use of chloropropyltriethoxysilane in combination with biotemplates for the formation of a functionalized organosilicon material

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The utilization of biomimetic mineralization methodologies by researchers has given rise to the development of various composites that exhibit exceptional chemical and physical properties, controllable structures, and desirable biocompatibility. Sol--gel technology is regarded as one of the simplest and most promising methods for creating modern biocatalysts and porous carrier materials. The utilization of living microbial cells in combination with sol--gel technology allows for the production of hybrid biomaterials. A material containing functional groups can be created using chloropropyltriethoxysilane (CPTES), which contains a chloropropyl radical. The addition of further quaternary ammonium compounds or triazoles leads to the formation of an antimicrobial material with a contact-killing surface. A porous silicon-containing material with a sufficiently large specific surface area can be created using microorganism cells. This makes it possible to obtain a promising, two-in-one antibacterial material that releases the active substance and destroys microorganisms upon contact.

In this study, the yeast strain *Ogataea polymorpha* BKM Y-2559 was immobilized in organosilicon biomimetic shells with varying volume ratios of chloropropyltriethoxysilane (CPTES) and tetraethoxysilane (TEOS). The formation of polymeric organosilicon matrices was confirmed by infrared spectroscopy. The architecture and elemental distribution on the surface of the obtained materials were established by scanning electron microscopy and energy-dispersive spectroscopy. Immobilization efficiency was determined by measuring the sensitivity characteristics of the biosensor, for which encapsulated yeast cells were used as the biomaterial.

It was determined that the *Ogataea polymorpha* BKM Y-2559 yeast strain can be used as a biotemplate, and that the most suitable silane precursor composition for encapsulation is a CPTES/TEOS ratio of 95:5 (vol.%). The chloropropyl radical stays in the material after the cells have been removed with N-methylpyrrolidone.

The resulting material can serve as an intermediate platform for the further synthesis of a functionalized carrier for loading antiseptic or medicinal substances.

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Session 4. Bioinspired Architecture

sciforum-133850: Biophilic Design for Sustainability: Development of a Design Framework Using Bio-inspired Processes

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As sustainability challenges in the built environment intensify, there is an urgent need to adopt Environmentally Sustainable Design (ESD) that moves beyond conventional energy efficiency and toward regenerative, nature-integrated solutions. Biophilic design, which seeks to restore connections between people and nature in the built environment, offers a promising pathway. Current BD practice tends to emphasise sensory perception and human–nature connection, while ESD practice is more performance-oriented, focusing on measurable outcomes such as energy efficiency, water management, and material optimisation. This paper introduces the Biophilic House Guide, a design framework developed to bridge these two approaches by integrating natural processes as common ground for design innovation.

The framework is structured around five categories: Earth (materiality and resource cycles), Water (hydrological systems), Air (quality, ventilation, and thermal comfort), Fire (energy and light systems), and Habitat (biodiversity and social inclusion). Within each category, bio-inspired strategies were identified from ecological processes and translated into practical design criteria that can simultaneously enhance building performance and strengthen biophilic qualities. For example, Earth strategies draw on soil regeneration to inspire circular material flows, Water strategies model natural wetlands to improve stormwater management, Air strategies adapt termite mound ventilation to achieve passive cooling, Fire strategies emulate plant morphology for solar capture, and Habitat strategies replicate forest edge conditions to foster multispecies living environments.

This paper discusses both the methodological development of the guide and its practical implications. Findings highlight that integrating BD and ESD through bio-inspired strategies allows designers to move beyond aesthetic or symbolic uses of nature towards regenerative solutions that are grounded in ecological performance and human well-being. This novel framework, the Biophilic House Guide, offers a replicable model for residential architecture, bridging human sensory experiences with sustainability outcomes and demonstrating how biophilic processes can support the transition to regenerative design practices.

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sciforum-133424: Astroarchitecture

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This paper examines the emerging field of mycotecture, the application of fungal mycelium as a structural material, for the construction of extraterrestrial habitats, with particular emphasis on its feasibility for lunar environments. Grounded in the principles of in situ resource utilization (ISRU), mycotecture presents a lightweight, biodegradable, and resource-efficient alternative to conventional building materials, offering significant reductions in payload mass for long-duration space missions. This study assesses the architectural, ecological, and biotechnological potential of living fungal systems. Fungal species such as Ganoderma lucidum have demonstrated the capacity to form robust biocomposites when combined with lunar regolith simulants, while extremophilic organisms like Cryomyces antarcticus exhibit remarkable resistance to high radiation levels. Building on this potential, NASA's Mycotecture Off Planet initiative has proposed a multi-layered habitat prototype incorporating ice for radiation shielding, cyanobacteria for oxygen generation, and a self-growing mycelial shell for structural support. These biologically integrated systems embody a regenerative design paradigm that converges architecture, synthetic biology, and sustainability. However, key technical challenges persist. The behavior of fungal growth under lunar gravity remains poorly understood; the long-term durability of mycelial materials in vacuum conditions has yet to be validated; and strict biocontainment measures are necessary to avoid forward contamination. Despite these limitations, mycotecture holds transformative potential for both space and Earth-based construction, offering a circular, carbon-negative approach to habitat design. By advancing this biologically driven architectural model, this study highlights mycotecture as a promising framework for regenerative, adaptive, and symbiotic living environments in extraterrestrial and terrestrial contexts alike.

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sciforum-142293: Paradigmatic Shift in Perception of Beuty in Architecture and Design: Mycelium-Based Composites Case Study

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In light of growing ecological awareness and the urgent need to address climate change, contemporary architecture and design are undergoing a paradigmatic shift in the perception of beauty. This shift moves beyond traditional ideals of permanence, symmetry, and polished industrial materials toward aesthetics rooted in sustainability, ecological responsibility, and regenerative design. This study explores the role of mycelium-based composites (MBCs)—biodegradable materials derived from fungal root systems—as catalysts of this transformation.

The research employs a qualitative, interdisciplinary methodology combining case study analysis with secondary analysis of survey-based studies on material acceptance among architects and design students. Case studies were selected according to three criteria: recency (projects realized within the last decade), experimental or exhibitional character (installations and prototypes showcased at design festivals and exhibitions), and demonstrable engagement with ecological aesthetics. Within this framework, this study focuses on projects such as *Living Mycelium Dunes*, *Growing Pavilion*, and *Living Cocoon*, which exemplify how MBCs manifest themes of organic texture, sensory richness, ephemeral beauty, biomimicry, and modularity. These qualitative attributes were analyzed not merely as formal characteristics, but as expressions of broader aesthetic paradigms.

The theoretical underpinning of this study draws on discourses in sustainable aesthetics and biophilic design (Pallasmaa, 2009; Nowakowski, 2024), which argue that beauty emerges from integration with natural processes rather than domination over them. By situating mycelium within this aesthetic framework, the analysis demonstrates how its material qualities—growth, decay, and regeneration—redefine beauty as cyclical and processual.

In parallel, survey data from architects and students indicate an increasing acceptance of MBCs, especially among younger professionals, who associate beauty with ecological harmony and material life cycles. These findings support the notion that the paradigm shift in aesthetics is both material and cultural: materials like mycelium are valued not only for their visual and tactile qualities, but also for their symbolic and ecological significance.

This study concludes that MBCs embody a new aesthetic vocabulary where transformation, impermanence, and regeneration are central. They not only redefine material aesthetics but also encourage a broader cultural shift in architectural beauty—one that aligns design with ecological responsibility and the rhythms of the natural world.

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sciforum-142540: Tejiendo con Seres de la Tierra: Co-Weaving a Biohybrid Mishki Wasi with Kuriñampi and Samaruta for the Living Forest (Kawsak Sacha) of the Amazon

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All life forms are entangled in symbiotic, multispecies relations that actively sustain ecosystems under threat. At times, humans become part of these entanglements, especially through collaborations with nonhuman beings, that require ecological literacy, situated care, and reciprocity—the ability to give as well as to receive.

In this context of ecological urgency, Weaving as Worlding Practices with Earth Beings (WeB)—*Tejiendo con Seres de la Tierra*—explores co-creation across two communities: the I.N.S.E.C.T. Community, a collective of Western scholars, artists, designers, and biologists; and the Sarayaku people, an Indigenous nation in the Ecuadorian Amazon, including the Samaruta youth and the Kuriñampi women's collective. Both engage in craft and design practices that challenge extractive notions of bioinspiration.

In the Pastaza region, Kuriñampi work with *mangallpa* (river clay) to create organic ceramic vessels like *mukawa*(drinking bowls) and *tinajas* (fermentation jars). Samaruta men use native liana in triaxial weaving to craft baskets, while the youth are known for environmental and cultural activism. Meanwhile, I.N.S.E.C.T. members gather annually in Hvalsø, Denmark, for a summercamp where one core activity is the practice of "critical making" focused on insect ecologies.

Together, we ask how reciprocity—giving to and receiving from other organisms—varies across geographic, political, spiritual, cultural, and ecological contexts. Through shared attention to local bees (*mishki*), particularly *Tetragonisca angustula* (*chullimpi*), we explore the ethics and aesthetics of multispecies gifting through the biohybrid design of bee shelters—*mishki wasi*.

As the three WeB researchers, we visited Sarayaku and introduced early artefacts initially called *Mukawa Wasi*—open-ended, more-than-human interfaces crafted from 3D-printed clay and biopolymers in Graz, Austria, and Quito, Ecuador. These shelters served as starting points for dialogue around *chullimpi* nesting. The artefacts served as invitations—inviting craftspeople to adapt and extend them using local techniques; inviting bees, microbes, and plants to inhabit them; and inviting Kawsak Sacha—the Living Forest—to respond in its own time and form. We also integrate vibration sensors, building on prior work by one of our collaborators who explored sound-based storytelling with ants, to attune more closely to the subtle life signs of bees.

WeB aims to weave institutional, scientific, and community alliances through shared learning and multispecies care. Social insects like bees and ants, as ecological indicators, guide our practices of cohabitation and knowledge exchange. By centering Sarayaku knowledge and biocentric values, WeB repositions Western design as a reciprocal, tactile practice—of listening, learning, and gifting.

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sciforum-134106: The Cosmic Spiderweb: Efficient architectural structures from natural flows

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The cosmic web is what we call the network of filaments between neighboring galaxies, and the membranes between these filaments. It has various descriptions; a dual description is a network of bubbles called voids, which expand at different rates and collide. Filaments, membranes, and galaxies arise at the interfaces of these bubbles; the matter flows analogously to how water flows on a landscape (I will mention some of our recent work about the cosmic equivalent of a “rainstorm”). Channels of matter (water, in the case of a river, or gas and dark matter, in the case of a filament) form where matter collects with other matter that may have originated far away. Channels form between literal hills on earth, or hills of the gravitational potential, in the cosmos. I will discuss some work about the identical geometric description of the cosmic web and structural spiderwebs, which are networks that can be strung up entirely in tension. Through a formalism called graphical statics, of which James Clerk Maxwell was a founding figure, structural spiderwebs naturally arise when material collects at interfaces between bubbles. I will also discuss some software employing this formalism, and the relationship between these structures and biological branching structures such as trees.

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sciforum-141461: The Vein Logic: Designing Smarter Drainage Systems Inspired by Nature

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Urban flooding poses a growing challenge due to rapid urbanization and changing rainfall patterns, revealing the limitations of conventional drainage systems. This study introduces a nature-inspired, biomimetic solution, the Vein Logic drainage system, modeled on the adaptive branching structure of leaf veins, which enables efficient flow distribution through redundant and flexible pathways. Using a simulation of the Île de la Cité area along the Seine, the traditional drainage system initially transported water over 644.6 m before stopping at blocked channels, representing approximately 40% of the total route required to reach the target and illustrating the inability of conventional systems to maintain flow under obstruction. In contrast, the Vein Logic system dynamically rerouted around obstructions and successfully reached the target over a longer path of 1,590.6 m. Although the adaptive path is longer, it ensures continuous flow under blockage, demonstrating the trade-off between distance and reliability inherent in nature-inspired design. According to literature values reported over recent years, conventional urban drainage systems can experience 20–80% flow interruptions under partial blockages, further highlighting the need for adaptive, resilient networks. Practical implementation challenges are acknowledged, including spatial constraints and costs when retrofitting existing systems, and design complexity and the need for specialized expertise for new builds, emphasizing the considerations required for real-world application. These insights, together with the simulation results, demonstrate the potential of biomimicry and nature-inspired design to enhance urban drainage and flood management in contemporary cities, providing resilient infrastructure capable of maintaining functionality under adverse conditions. Moreover, the principles demonstrated here can be adapted to other urban contexts where conventional drainage systems face similar vulnerability, supporting broader applications of nature-inspired solutions.

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sciforum-134088: A Conceptual Framework for an Allelopathic Cultivation Garden: Nature-Inspired Foundations for Sustainable Horticulture

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This conceptual framework is grounded in a profound engagement with the principles of biomimicry—an approach that regards nature as the ultimate teacher and model for design solutions—in the context of designing cultivation gardens that harness natural allelopathic processes. Allelopathy, a biochemical form of communication and interaction among plants, is regarded here as a pivotal mechanism that biomimetically replicates and integrates natural ecological strategies, ensuring balance, resilience, and productivity within agricultural systems. Within this framework, traditional knowledge of natural plant interactions, passed down through generations, is synthesised with contemporary scientific research to develop a holistic model enabling deliberate spatial planning, species selection, and crop rotation. This model emphasises the importance of understanding plant-to-plant biochemical relationships to create synergistic plant communities that suppress weeds, deter pests, and promote mutual growth without reliance on synthetic chemicals. Such an approach not only contributes to reducing chemical inputs but also supports soil health, biodiversity, and ecosystem stability, thereby advancing regenerative horticultural practices. By emphasising the biomimetic nature of the concept, this work demonstrates how the careful recreation and adaptation of natural processes can form the foundation of modern, sustainable, and regenerative horticulture. This aligns with broader global efforts to address environmental challenges, promote sustainable resource management, and foster resilient agricultural landscapes for future generations.

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sciforum-142059: Biomimetic Distribution Systems: Investigating the Building of Water Supply Systems Through A Study of the Xylem Network

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With a step towards sustainability every day, biomimicry is becoming an increasingly important field of study. In parallel, it is beneficial to aim towards a higher efficiency target in our man-made building services to consume as littleenergy as possible. This study investigates the potential of biomimetic principles in enhancing water supply systems within multistoried buildings by drawing parallels with the water transport mechanisms of Ficus religiosa (peepal tree). Specifically, it compares the efficiency of natural xylem-based flow with traditional plumbing systems through both qualitative and quantitative analyses. By examining the structural and functional characteristics of natural xylem networks, this research underscores the potential of nature-inspired solutions to inform future architectural design and advance sustainable building services.

The results indicate a complex and multifaceted problem, examined through three primary aspects: constitution, secondary anatomical features, and hydraulics. Key factors such as hydraulic conductivity, height-to-diameter ratio, flow rate, and pressure gradients reveal the intricacy of the system. The analysis incorporates theoretical formulations, including the Hagen–Poiseuille equation, alongside an evaluation of inherent sustainability, to provide a comprehensive basis for comparison.

Findings highlight the adaptability of the Ficus group, which employs strategies such as large vessel diameters, base-to-tip widening, and hydraulic adjustments that enable efficient long-distance water transport. These analogies suggest opportunities for reducing energy consumption and minimizing wastage in engineered plumbing systems.

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sciforum-134213: Coastal Resilience through Bioinspired Architecture in Bangladesh

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Introduction

The coastal areas of Bangladesh face serious problems due to climate change. They are often hit by cyclones, tidal surges, and saltwater intrusion.(Eckstein et al., 2021). Traditional infrastructure often does not provide lasting support in vulnerable areas. This study looks at how bioinspired architecture and nature-based solutions (NBS) can help create climate-friendly and sustainable designs for coastal Bangladesh. It focuses on utilising natural concepts to enhance building design and functionality. (Pawlyn, 2011; Raymond et al., 2017).

Methods

A multi-method approach was used, combining qualitative field research, participatory interviews with coastal residents, and ecological mapping. This provided insights into community perspectives and ecological dynamics. A seven-stage co-benefit assessment framework was applied to evaluate how environmental health supports social resilience and economic vitality in coastal areas. (Raymond et al., 2017) guided the evaluation of architectural strategies in terms of environmental impact, community resilience, and policy integration. Biomimetic inspiration was drawn from natural systems such as mangrove root networks, forest edge layering, and leaf morphology, which were abstracted into functional design elements (Benyus, 1997; Badarnah, 2017).

Results

The study reveals that bamboo stilt housing, when thoughtfully modified with bioinspired structural principles, demonstrates a substantial enhancement in flood resilience. By incorporating layered defensive landscaping that mimics the natural stratification found in forests, these structures create an effective buffer against the destructive forces of high winds while concurrently fostering biodiversity. This innovative approach not only protects the housing from potential flood damage but also supports a rich ecosystem, allowing various plant and animal species to thrive in harmony with human habitation.(Sohaana & Rahman, 2021). These strategies also improve microclimate control and reduce energy use. Participatory processes enhanced social cohesion and contextual relevance.

Conclusions

Bioinspired architectural and landscaping strategies offer a scalable and regenerative solution to climate risks in Bangladesh's coastal belt. By integrating ecological patterns into architectural systems, these approaches transform the built environment into a co-evolving partner with nature, reinforcing resilience, sustainability, and human well-being.

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sciforum-133714: Development of Biomimetic Strategy-focused, Decision-Support Tool for Regenerative Urban and Architectural Planning

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This paper presents the development and early-stage evaluation of a biomimetic-focused decision-support tool designed to support regenerative urban and architectural planning. Grounded in the principles of urban metabolism and ecological systems, the tool aims to help stakeholders—architects, planners, and policymakers—to identify and apply nature-inspired strategies to challenges across various spatial scales (urban, building, and building component scales) and across multiple urban systems, including, but not limited to energy, water, waste, and mobility. The tool is built on a curated relational database of 184 biomimetic strategies, each summarised as a visual pattern card and linked to a digital interface built in Power BI. Users can filter strategies by application scale, urban system, environmental performance goal, and other implementation considerations such as cost and time. To evaluate the tool's usability and guide its development, semi-structured interviews were conducted with eight experts from the fields of architecture, policy, and urban planning. The findings suggest that the tool supports systems thinking, enhances understanding of biomimetic strategies, and facilitates more holistic planning across application spatial scales and urban systems. Interviewees also highlighted the potential of future integration with AI. At the same time, experts identified three key improvement areas: the need for stronger cost-performance framing, visual clarity, and clearer interaction pathways. This paper presents a work in progress of the tool's prototype and demonstrates its clear potential in making biomimicry actionable in regenerative urban transformation. As a participatory and exploratory platform, the tool provides promising steps toward supporting a shift from fragmented sustainability efforts to integrated regenerative planning.

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sciforum-142148: Exploring Adaptive Building Façade Designs Inspired by Natural Systems: A Literature Review and Prospective Application for Energy Efficiency in Indian Architecture

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The pursuit of sustainable architecture has intensified the exploration of adaptive building façades that dynamically respond to environmental stimuli, aiming to improve energy efficiency and occupant comfort. Nature offers numerous examples of such adaptive systems, with the hygroscopic movements of pine cones serving as a prominent model for bioinspired façade designs. This paper presents a comprehensive literature review of bioinspired adaptive façades, synthesizing recent advancements in smart materials, mechanisms, and control strategies. It explores how principles such as self-regulation, responsiveness, and material efficiency found in natural systems can inform innovative architectural solutions to mitigate the energy demands of buildings. Particular emphasis is placed on the contextual relevance and potential application of these adaptive façades within India's diverse climatic zones, ranging from hot and arid to tropical and humid environments. Socio-economic and cultural factors influencing the adoption of such technologies in Indian architecture are also discussed. This review identifies critical research gaps, particularly the need for region-specific studies and cost-effective materials suitable for large-scale implementation. A conceptual framework is proposed to guide future research and design efforts aimed at integrating bioinspired adaptive façades into mainstream Indian architecture. By bridging biological insights with architectural innovation, this study contributes to the discourse on energy-efficient, resilient, and sustainable built environments tailored to local conditions. This review aims to inspire architects, researchers, and policymakers to further develop and adopt biomimetic adaptive façade technologies that align with India's sustainable development goals.

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sciforum-124892: Exploring Living Architectures with Microbial Cement Supercapacitors

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For millennia, cement has been regarded as an inert structural material. Here, we challenge this long-standing perception by transforming cement into a “living” energy device, pioneering a new class of microbial cement supercapacitors. By embedding electroactive microorganisms within cementitious matrices, we introduce a biohybrid system that stores charge through microbial redox activity and extracellular electron transfer. This material not only retains its mechanical robustness but also gains dynamic energy functionality, enabling a new category of building elements that combine structural and electrochemical performance. Notably, the embedded microbes remain electrochemically active over time and can be reactivated via nutrient infusion through an integrated microfluidic network. This responsiveness opens up the possibility for cyclic regeneration and sustained charge transfer, introducing an element of temporal behavior into otherwise static construction materials.

While this research remains in its early stages, it offers a compelling proof of concept for integrating living systems directly into architectural materials. By leveraging biological intelligence within structural matter, we move toward a future in which built environments are not only passive shelters but responsive, energy-aware entities capable of interacting with their surroundings. Our findings redefine how we understand, design, and utilize construction materials, contributing to the broader discourse on sustainable, adaptive, and multifunctional infrastructure in the age of climate and resource challenges. This work opens new perspectives for designing living architectures that merge structure, function, and biological agency into a unified material paradigm.

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sciforum-133605: Mangrove-Inspired Timber Terraces for Urban Flood Resilience and Biodiversity Corridors

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Introduction

Coastal cities face escalating flood risks and ecological degradation as sea levels rise and impervious surfaces proliferate. Mangrove forests naturally attenuate wave energy and foster rich intertidal ecosystems through their buttressed root networks. This study translates mangrove root morphology into stepped timber terrace modules to enhance urban flood resilience while establishing biodiversity corridors in coastal urban waterfronts.

Methods

A parametric model of terrace geometry was developed in Rhino/Grasshopper, replicating key root buttress angles and spacings observed in *Rhizophora* species. Computational fluid dynamics (CFD) simulations in OpenFOAM evaluated energy dissipation, flow velocity reduction, and sediment transport under hydrographs representing 1-in-10-year and 1-in-100-year storm events. Pilot terraces—each 5 m wide, 0.6 m high, and composed of sustainably harvested glulam planks—were installed along a tidal creek in Lusaka's simulated coastal analog. Pre- and post-installation topographic surveys measured bed scour and deposition, and biodiversity assessments employed quadrat sampling of benthic invertebrates and opportunistic fish counts over a six-month tidal cycle.

Results

CFD results indicated up to a 45% reduction in peak flow velocity and a 30% increase in upstream water stage during extreme events, compared with unmodified embankments. Sediment transport models projected a 22% rise in depositional volume behind terraces, corroborated by field surveys showing an average 18 mm sediment accretion per tidal cycle. Biodiversity surveys recorded a 65% increase in invertebrate species richness and a 40% rise in juvenile fish abundance within terrace zones versus control sites. Structural monitoring confirmed that the timber modules endured cyclic tidal loading without significant deformation or joint fatigue over six months.

Conclusions

Mangrove-inspired timber terraces effectively dissipate flood energy, promote sediment accumulation, and create functional habitat corridors in urban coastal contexts. The modular, bioinspired design leverages sustainable timber resources and parametric modeling to deliver scalable, low-impact interventions. Future research will examine long-term durability, integration with green infrastructure networks, and social acceptance in diverse urban settings.

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sciforum-140542: The Permeability of a Soil Termite [*Macrotermes gilvus* (Hagen, 1858)] Fungus Comb as a Porous Medium

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In the field of biomimicry, termite mounds serve as a source of inspiration for engineers and architects involved in designing environmentally friendly buildings. For this study, baseline data were collected on the permeability properties of a biological porous material—a termite fungus comb. This study aimed to determine the air permeability of the comb by conducting experiments involving an air flow through an internal pipe and analyzing the effects of different air flow velocities with Reynolds numbers ranging from 15,000 to 71,000. Through the use of image processing, a detailed geometric structure was observed. The specimens have a porosity ranging from 52% to 61%, indicating that they are highly porous and have large pores. There are also variations in the size of each specimen associated with the equivalent diameter, with an average value of 5.16 mm. In addition, the results demonstrate that the tested specimens' permeability values varied from 1.2724×10^{-7} to 3.9828×10^{-7} m^2, with an average value of 2.235×10^{-7} m^2, as determined by the Forchheimer equation. Although this study was the first to characterize a termite fungus comb, it is recommended that additional research and evaluations be conducted to thoroughly investigate the characteristics and capabilities of this uncommon biological structure. Translating the properties of termite combs to the architectural scale assumes that their porosity, air flow dynamics, and structural stability scale predictably. Challenges include material differences, environmental variability, and manufacturing precision. Limitations also arise from potential discrepancies in the thermal performance and durability when replicating biological structures with conventional construction materials.

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sciforum-132832: The Transformative Potential of Biomimicry for Sustainable Construction: An Exploratory Factor Analysis of the Benefits

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Due to its significant environmental impact, the built environment faces growing pressure to transition toward more sustainable practices. Biomimicry, a novel field of practice that entails design and innovation inspired by nature's time-tested strategies, offers a promising pathway to enhance sustainability in construction. Hence, this study explores the perceived benefits of applying biomimicry principles within the construction sector, aiming to identify the key dimensions underpinning its transformative potential. An exploratory factor analysis (EFA) was conducted based on data collected through a structured questionnaire survey administered to 120 purposively sampled, duly registered, practising construction and biomimicry professionals in South Africa. The instrument captured perceptions of environmental, economic, and socio-functional benefits of biomimicry adoption and implementation. The EFA revealed four principal factors: socio-economic and health benefits, ecological resilience, performance enhancement and green market efficiency. These four factors cumulatively accounted for approximately 70% of the total variance, indicating a strong internal structure of the perceived benefits. The findings demonstrate that stakeholders perceive biomimicry as a tool for reducing environmental footprints and as a catalyst for innovation, circularity, and regenerative design practices in the built environment. This research contributes to the emerging discourse on biomimicry in the built environment by providing empirical evidence on its multifaceted value. It highlights the importance of integrating natural design intelligence into construction to foster more adaptive, efficient, resilient and sustainable systems. This paper recommends policy support, interdisciplinary collaboration, and further research to operationalise biomimicry within mainstream construction processes.

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sciforum-130150: Uncoding the Biomorph: A Post-Algorithmic Approach to Bioinspired Architectural Design Intelligence

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Bioinspired design in architecture has long relied on algorithmic abstractions of natural systems — from branching patterns in L-systems to evolutionary and swarm-based optimization models. While these approaches have generated visually compelling structures, they tend to reduce the richness of biological intelligence into symbolic and deterministic operations. This results in a design culture that often privileges formal mimicry over behavioral fidelity.

This paper deepens that critique by moving beyond comparisons of specific algorithmic models to address a broader epistemological issue: the **reduction of biological processes into computational schemas that favor visual replication over behavioral understanding**. Architectural applications of bioinspired algorithms often operate through linear logic, rule-based control, and predefined evaluation criteria—abstracting the dynamics of natural systems into deterministic, formal outputs. In doing so, they overlook key attributes of biological intelligence such as **contextual feedback, uncertainty, and adaptive responsiveness**. These characteristics are not peripheral but central to the generative logic of living systems, and should form the basis of biomimetic integration in architectural design.

To propose an alternative, this research explores AI-driven inference models — such as generative diffusion networks, flow-based embeddings, and latent space interpolations — as methods to reconstruct biologically-informed spatial behavior without relying on prescriptive rules. These models are trained on curated datasets of biological morphologies and movement patterns to extract underlying logics rather than static appearances.

Two design experiments are presented: one at the pavilion scale, where form growth is compared between L-system/simulation-based shells and diffusion-informed membranes; and one at the floor plan level, where conventional GA-based spatial optimization is contrasted with AI-inferred layout generation based on behavioral flow. Visual mappings and critical diagrams serve to unpack how each approach encodes growth, constraint, and adaptation.

Ultimately, this paper advances a speculative yet grounded framework for **post-algorithmic bioinspired design**, in which architecture moves beyond coding nature's image toward **learning from its intelligence through holistic reverse engineering**. It invites a methodological shift — from designing with symbolic algorithms toward designing with **learned biologic behavior**, unlocking new potentials for form, responsiveness, and meaning in architectural computation.

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Session 5. Bioinspired Robotics

sciforum-141643: An analysis of the dynamic metastasis mechanism in liver cancer cells based on a biomimetic microfluidic vascular network

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Liver cancer is one of the most common and lethal malignant tumors worldwide, of which hepatocellular carcinoma (HCC) accounts for 80%. Most HCC patients are already in the middle or late stages when diagnosed, having missed the best time for treatment. However, the existing diagnostic methods for this disease cannot reveal its dynamic mechanism and also have disadvantages such as detecting incurable disease, a poor effect, side effects, and high costs. Thanks to microfluidic technology, in this article, a biomimetic capillary network is designed and fabricated to reproduce the microenvironment of the capillaries in vitro. The topology of the biomimetic microcapillary network plays a crucial role in investigating the metastasis mechanism in liver cancer cells. The smallest capillary has a diameter between 12 and 13 μm, and the network of capillaries is connected to a main inlet or outlet channel with a diameter of 50 μm.

Firstly, simulation results for the microfluidic behaviors within the microcapillary network were established to analyze the influence of the topology and its microenvironment on the cells' microcirculation characteristics. As the flow rate was equal to 10 μL/min, applying Poiseuille flow theory, the linear relationship between pressure and flow was taken into consideration: the velocity of the flux at the inlet was 12.03 μm/s. Equally, the difference in pressure between the inlet and the outlet as well as the fluidic viscosity are taken into account. In general, the flow rate of the cell suspension decreases as it passes through the network. Secondly, several methods for fabricating the biomimetic microvascular network were compared: thanks to a combination of maskless direct laser writing and backside lithography, a biomimetic vascular network with a semicircular cross-section and a highly gradual gradient was produced. Finally, the cells' circulation within the microfluidic network is observed and analyzed to estimate the bionicity of the vascular network. The velocity in the middle of the vascular network is 3 to 4 times slower compared to that on both sides of the capillaries.

Compared with the traditional detection methods, the biomimetic microfluidic vascular network developed in this study would be helpful for reproducing the microenvironment of a biomimetic vascular network, which is significant for studying liver cancer cell metastasis. This method can achieve high-throughput, dynamic, and accurate detection of multiple types of health indicators, which have important clinical value in improving the early detection rate for lung cancer and optimizing individualized treatment plans.

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sciforum-132190: Bio-Inspired Underwater Robots: A Review

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Bio-inspired underwater robotics is emerging as a transformative technology, offering new ways to explore and monitor aquatic environments more efficiently and gently. Drawing inspiration from marine animals such as jellyfish, fish, crabs, and octopuses, these robots replicate natural movement patterns to achieve superior propulsion, agility, and the ability to switch between different modes of locomotion. Unlike conventional underwater vehicles, these soft and flexible designs allow for smoother navigation in complex environments. Recent progress in materials science, actuation technologies, and intelligent control systems has made these robots more adaptable and capable of functioning across varied underwater scenarios. This review provides a detailed look into the latest advancements in bio-inspired underwater robotics, highlighting essential design concepts, smart actuation methods, and control strategies that mimic the intelligence of natural organisms. It also explores their growing real-world applications, from delicate underwater inspections and marine research to complex search-and-rescue operations. By examining notable innovations such as jellyfish-inspired robots designed for energy-efficient movement and modular, magnetically actuated designs that can adapt to specific tasks, this paper showcases the field's dynamic progress. Ultimately, this paper aims at offering a clear understanding of current capabilities while identifying the key challenges and research gaps that must be addressed to bring these promising technologies into broader, practical use.

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sciforum-142547: Pollination process with collaborative robotic platform

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This study introduces a robotic pollination approach designed to address the decline of natural pollinators and enhance agricultural productivity. The system integrates a mobile robotic platform, a collaborative robotic arm, and an RGB-D camera for vision-based flower detection. It autonomously navigates to target plants, identifies fully bloomed flowers, and executes pollination through precise end-effector control. Motion planning is achieved using an Incremental Roadmap (IRM)-based algorithm, which generates collision-free trajectories to avoid damaging delicate flowers and surrounding plant structures. The platform was tested in an indoor setting, where it successfully demonstrated flower localization and effective pollination within a controlled environment. These results confirm the feasibility of using autonomous robotic systems for pollination tasks, providing a consistent and efficient alternative to manual or natural pollination methods.

While the system achieved promising results in controlled conditions, adapting it for real-world agricultural environments remains a key challenge. Future work will focus on enhancing robustness under variable lighting, irregular plant geometries, and dynamic conditions that are typically encountered in greenhouses or open fields. Improvements in vision algorithms, real-time environmental perception, and adaptive motion planning will be essential for ensuring operational reliability. Additionally, the integration of advanced machine learning techniques could further optimize flower detection accuracy and pollination efficiency across diverse crop types.

Overall, this research demonstrates the potential of robotic pollination systems as a scalable, sustainable solution for modern agriculture. By combining advanced sensing, motion planning, and AI-driven decision-making, these systems could significantly reduce labor dependency, improve pollination consistency, and contribute to higher crop yields.

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Session 6. Bioinspired Arts

sciforum-129820: *FadingColours*: An Interactive Installation Connecting Algae Cultures with Real-Time Coral Bleaching Data

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FadingColours is an interactive installation that connects living algae cultures with real-time data from NOAA's Coral Reef Watch, a satellite-based monitoring system for coral reefs worldwide. Coral reefs depend on a symbiotic relationship with algae for nutrition and colour. Under environmental stress, such as rising sea temperatures, corals expel the algae, leading to bleaching and, potentially, reef collapse. While this ecological crisis is well-documented, it often remains abstract and invisible to the public.

The installation translates the bleaching conditions of five coral reef locations into the living responses of algae cultures contained in transparent vessels. Each vessel is assigned to a specific reef monitored by Coral Reef Watch and responds to its current bleaching alert level. Stress levels from each reef are translated into subtle changes in the vessels, making the environmental stress of each reef observable through the algae's living response. The algae's responses are complemented by a colour-coded indicator that reflects the current bleaching level of each assigned reef. Together, the colour codes and the behaviour of the algae signal the severity of bleaching in each region.

Visitors can interact with a touchscreen map to explore the global status of coral reefs and access information bubbles detailing the condition of each site. Each of the 219 monitored reefs is accessible, and the installation includes multilingual audio narration designed to make coral bleaching accessible to younger audiences and non-specialists.

By linking living organisms to near-real-time data, *FadingColours* creates a tangible experience of distant ecological change. It invites reflection on the fragility of marine symbiosis, the invisibility of climate data, and the role of media art in shaping ecological awareness. The work foregrounds care, observation, and indirect interaction as modes of engagement with living systems and their environmental contexts.

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sciforum-129821: *MycoGravity*: A Robotic Installation for Observing Fungal Growth Under Altered Gravity Conditions

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MycoGravity is an artistic research project that explores how fungi grow and behave under altered gravitational conditions. At its centre is a robotic installation that simulates microgravity and partial gravity by moving a bioreactor containing living mycelium (*Pleurotus pulmonarius*) using a KUKA Quantec robotic arm. Inside this chamber, environmental factors such as temperature, humidity, CO_2, and bioelectrical activity are monitored using custom sensors and microcontrollers. A logging system records changes over time, enabling close observation of the mycelium's response to mechanical and environmental influences.

Fungi possess the ability to sense gravity, which is a phenomenon known as gravitropism. Fruiting bodies use this ability to grow upright, ensuring correct orientation for spore release. Yet, the mechanisms by which fungi sense and respond to gravity are not yet fully elucidated. MycoGravity offers a space to observe this response outside of the Earth's constant gravitational field. By rotating the mycelium chamber continuously or placing it into programmed patterns of movement, we can disrupt gravitational orientation and study the resulting behavioural changes. The mushrooms that grow under these conditions take on sculptural forms shaped by their environmental experience. These forms are exhibited as gravity-shaped sculptures.

This artwork contributes to ongoing conversations in astromycology, biosensing, and sustainable design, while also offering a material and visual encounter with the possibilities of shared adaptation between living systems and engineered environments. MycoGravity invites reflection on how we might engage with non-human life in unfamiliar settings such as outer space, through care, curiosity, and attention.

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sciforum-119645: Illustrated Amanita Domestication & Mass Production for Sustainable Industrialization of GMO Yeasts, Genetically Modified Intelligence, Mycomorphic Biorobots, AstroMycoCulture, superfoods, beverages, body care products, & beyond http://tinyurl.com/SciForumAmanitas

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Introduction

Current technologies raise significant ethical and environmental concerns due to energy-intensive infrastructure. This work, grounded in research spanning millennia of wild foraging impacts, a century of experimentation, scientific publications, patents, and initiatives from international space agencies and academic consortia, traces the evolution of genetically modified yeasts toward symbiotic and altruistic Genetically Modified Intelligence (GMI). Potential applications include Mycomorphic Biobots, AstroMycoCulture terraforming, and mycorrhizal electrical communication systems sensing environmental cues such as weather and movement patterns, with funding pathways through edible Amanita superfoods, beverages, body care, and therapeutic products.

Methods

We trained AI to create accurate infographic layouts and respectful depictions of minority cultural identities, countering erasure and exploitative stereotypes. The resulting inclusive commercialization engaged over 2,000 viewers between 2023 and 2025, enhancing engagement, comprehension, and long-term investment profits. Visual narratives illustrated natural and synthetic conditions for mycorrhizal propagation. Proposed experiments combine indoor mycorrhizal cultivation with outdoor grounding rods to preserve and monitor fungal network electrical connectivity. Tests will vary moisture, nutrient, and light regimes, compare gray water reuse to clean water controls, and record electrical signals with high-impedance differential amplifiers analyzed via Fourier transform methods under simulated rainfall and airflow. Co-cultivation with genetically modified yeasts will assess impacts on resilience, nutrient exchange, and self-repair.

Results

Anticipated outcomes include creative outputs such as living sculptures, music, and visual media. Grounding rod integration is hypothesized to enhance measurable electrical responses and support propagation in areas lacking native medicinal Amanitas.

Conclusions

Intersectional markets are expanding with scholars and consumers in myco-conscientious computational fungal-fiber optics and decentralized eco-architectures. Such bio-integrated circuits and cultivation systems could support interplanetary and intergalactic permaculture agroforests.

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sciforum-141867: Biomimetic Artistic Representation of Histological Tissue Morphology: A Scientific Approach to Visualizing Cellular Structures in Contemporary Visual Art

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The convergence of science and art in recent decades has generated new visual directions, especially in the sphere of bioart and biomimetic art. Histology, as the microscopic study of tissues, offers a formal repertoire of great complexity, characterized by regularity, modularity and interconnectivity. The present work investigates the aesthetic potential of histological morphology as a model for artistic creation, proposing the transposition of microscopic cellular configurations into abstract plastic compositions through a biomimetic approach. Visual analysis of high-resolution histological images representing epithelial, muscular and nervous tissues allowed for the identification of relevant features such as rhythmicity, stratification, fiber orientation and the extracellular matrix structure. Based on these observations, watercolor works on paper were created, a technique chosen for its ability to render the transparency and fluidity of biological structures. The results consist of a series of paintings that reflect a coherent visual logic derived from histological structures: layered compositions for epithelial tissue, directional shapes for muscular tissue and abstract synaptic networks for nervous tissue. The artistic interpretation does not aim at exact anatomical rendering but rather proposes an abstraction that preserves the organizational principles. This study confirms the relevance of histological morphology as an aesthetic and conceptual model, demonstrating the potential of the biomimetic method to build a bridge between science and art within contemporary visual practices.

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sciforum-130012: Galls, Genes and Growing Devices: Bioinspired Art and the Vision of Programmable Plants

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Biomimetics—learning from Nature for applications in science, engineering, and the arts—can inspire advanced technologies and transformative ideas for education and societal change. This presentation bridges biomimetics and conceptual art by focusing on a little-known natural phenomenon with extraordinary design potential: plant galls.

Galls are intricate structures formed on plants in response to external agents such as insects, bacteria or fungi. Certain wasp species, for example, can selectively reprogram plant tissues using biochemical signals that make the host plant grow a complex, protective nursery for their larvae. These gall structures often feature sophisticated designs: bitter compounds that deter herbivores, exit holes pre-installed for the mature insect, and, in some cases, even ejection mechanisms that launch the gall into the soil, where the transformation to adulthood continues. These processes resemble programmable biofabrication—where genetic and biochemical instructions from one organism guide another to construct a bespoke physical object.

Inspired by these natural marvels, a biomimetic art-education concept designed for middle school students in the field of “Technology and Design” is proposed. The goal is to stimulate young minds to see Nature not merely as scenery or resource, but as a responsive co-designer. Through creative visualizations—such as insects "convincing" plants to grow tiny spaceships or imagining future tools launching from leaf surfaces—we introduce the foundational idea of *programmable living materials*.

This artistic-conceptual installation and educational framework could ultimately spark ideas for bio-inspired manufacturing of the future: growing tools, furniture or even dwellings from pre-coded seeds. The children would begin to envision a world in which products are not assembled but cultivated—merging design with ecology, and engineering with empathy for life.

The talk will present visual material, theoretical framing and first steps in the pedagogical development of this approach. By integrating science, technology and speculative design, the project invites fresh perspectives on sustainability, biomimetics and the living fabric of the planet as a source of future innovation.

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sciforum-134494: Bio-informed design in practice: Are current processes aligning with the needs from practice?

Nariman Lotfi

Loughborough University

Bio-informed design processes have steadily advanced, yet research on effective processes for industrial methods remains limited. Practitioners report a disconnect between industry needs and the current processes available. They are motivated to develop their own bio-informed design processes primarily due to the need for flexibility and integration with existing workflows. Industry professionals value tools and processes that can be adapted to their specific project requirements, personal skillsets, and company expectations. Standardized or rigid processes are often difficult to implement in diverse industrial contexts, prompting practitioners to customize or combine multiple tools to better fit their needs. This study explores the motivations of practitioners for adopting bio-informed design and examines their practical approaches to implementing these processes. Through semi-structured interviews with professionals actively engaged in bio-informed design, the research reveals that practitioners often develop individualized methods due to the lack of standardized processes that adequately address real-world requirements. Motivated by the need for flexibility, relevance, and alignment with industry demands, practitioners tailor their workflows to better integrate bio-informed principles into their practice. Intrinsic motivation also plays a significant role; practitioners are often driven by a strong interest in sustainability and a desire for creative freedom. The ability to exercise control and autonomy in the design process fosters creativity and encourages practitioners to tailor their own methodologies. The findings highlight the practical adaptations made by practitioners and underscore the importance of developing processes that reflect the complexities and needs of professional bio-informed design. Finally, collaboration across disciplines, such as between biologists and engineers, further motivates the development of individualized processes to bridge gaps in goals, timelines, and communication styles. The study, therefore, proposes further alignment between research in the field of bio-informed design as well as current ongoing practice.

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sciforum-144173: Living Systems, Moving Bodies: Bioinspired Choreographic Processes in Contemporary Dance

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Federal University of ABC

Contemporary dance provides fertile ground for reimagining movement through principles and dynamics derived from nature, where evolution has produced highly efficient and adaptive mechanisms across diverse and often extreme environments. This work investigates how biological strategies, processes and interactions can be translated into choreographic tools not only at the level of form and imagery but also within the deeper structures of movement, body language and rhythmic accent in performance. Drawing on phenomena such as collective swarm behavior and using algorithmic methods to reduce motion noise, this work examines how biological principles can inform the generation, organization and evolution of choreographic processes. Rather than merely illustrating nature, this approach treats biology as an inspirational library that supports new conceptual visions. It offers choreographers an expanded vocabulary of movement while opening possibilities for transformed relationships between dancers and space; within the dancers themselves; and in their connections with audiences. With the introduction of added variables and extra degrees of freedom, choreography extends beyond the composition of movement sequences to emerge as a living inquiry, a dynamic experiment into how systems move, respond, adapt and evolve. By applying the intelligence of natural systems to the language of dance, this research also fosters new pathways for interdisciplinary collaborations, and it affirms dance as a vital space for exploring how nature can inspire future forms of artistic expression. It contributes to the development of methods that integrate artistic practice with scientific knowledge and may converge toward novel approaches in the performing arts, where creative expression is informed by the adaptive logics of living systems.

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sciforum-130237: ZOE: Real-Time Interaction Between Reishi Mushrooms and custom-made Robotic System

Noor Stenfert Kroese [1,2,*], Amir Bastan [1] and Johannes Braumann [1]

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ZOE is a temporary co-existence between reishi mushrooms (*Ganoderma lucidum*) and a custom-made robotic system. The artwork explores the possibilities of internal communication between a robotic system and fungi. Within this seeming paradox of nature and technology, an ecosystem emerges in which both affect and care for one another through sensing technologies. The project continues on to research the interaction and unknown communication within fungal mycelia networks.

ZOE uses sensors to collect data from both the environment and the mycelium of the reishi. This data mediates a form of internal communication between the mushrooms and the robotic system. The behavior of the reishi influences the robotic responses, while the robot, in turn, affects the shape of the light-sensitive fruiting bodies over time. This reciprocal influence becomes visible in the morphology of the mushrooms, sculpted through ongoing interaction.

Alongside real-time visualisations, the project also explores tactile engagement with data through the *Mushroom Data Carpets,* daily hand-tufted translations of fungal and environmental signals. These physicalisations of the data do not aim to explain the data, but to stay close to its ambiguity. Offering an alternative to conventional visualisation, they support a slower, more reflective mode of engagement and contribute to a growing interest in sensorial approaches to data in the arts and art-based research.

ZOE is the first step in an ongoing interdisciplinary research project called *Mycobotics*. The project investigates how fungi, robots, and humans can interact through parallel, asynchronous, and context-driven processes. Rather than relying on direct input–output feedback, it examines how autonomous agents influence one another indirectly through shared environmental conditions. It explores whether fungal mycelium, through its sensing properties and electrical activity, can function as an active component in real-time robotic systems. By developing sensor interfaces and adaptive robotic behaviours shaped by fungal signals, *Mycobotics* aims to establish experimental systems in which living organisms and machines operate as co-constitutive agents within responsive environments of sensing, adaptation, and interaction. We introduce the framework of *parallel interaction*, which shifts the focus from direct causality toward indirect influence through shared environmental conditions. This allows for an artistic practice where the outcome is not predefined, but continuously shaped by unfolding processes across biological, machinic, and human actors.

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