Ybl Journal of Built Environment, Volume 9. Issue 1. (2024)
10.2478/jbe-2023-0003

BIOMIMICRY ARCHITECTURE BETWEEN FAME AND REALITY

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Abstract: *As a highly interdisciplinary subject, architecture is influenced by many natural and social science subjects. Although seemingly distant from architecture, biology is currently a scientific field that fits into design practices that have evolved and shifted towards a new hybrid framework. Architecture is a complex negotiated cultural practice that encompasses all aesthetic, technical, economic, and political issues of social production itself. For architects, the integration of academic knowledge and design practice can be a difficult activity to define, but it can be the intellectual fuel that drives innovation and growth in architectural practice. The relationship and connection between architecture and nature have generated many questions, criticisms, and solutions. Today, a new form of design was introduced a few years ago, forcing the modern man to be inspired by decades of natural processes, but whose true potential has only recently been revealed.*

Keywords: *Architectural Design, Biomimicry, Nature and technology, interdisciplinary*

1. INTRODUCTION:

There are several historical examples of bio-inspired architecture, but recently a biomimetic architecture movement is attempting to further advance this design practice by integrating a scientific approach that incorporates contemporary life sciences to respond to current environmental challenges. It is really interesting to wonder how nature is making things, what if we can produce buildings out of environment-friendly materials that can vary their properties by responding to exterior factors, changing their façade thickness, temperature, and color, and working hand in hand with air and sun rays? It is A building inspired, informed, and engineered by nature, that can grow by itself forced by nature, or by design [1].

Because of computational design, additive manufacturing, and synthetic biology, we can, in this era, change our way of thinking about the future of machines to the future of biology [2], we have the essential materials to learn more about natural systems in both micro and macro scales, as they are the best options and solutions for the human being, to recreate and imitate them.

By benefiting from technology and understanding how nature is operating, we will be able to move away from the concept of assembly and get closer to the initial system of nature which is growth. A test case focusing on, tree structures, duct designs, and building facades is presented and analyzed to see the application of the proposed approach.

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1. BIOMIMICRY IN ITS BEGINNINGS:

The biomimetic design process is bi-directional, analog-based, and interdisciplinary. Bionics experts currently agree that there are two possible approaches: either we start from a design problem and try to find strategies in nature that we could transfer to solve the design problem, or we seek new inventions with our interest and look for strategies in nature, and try applying them to new design methods or products [6].

Figure 1. Biomimicry Design Principles, Done by the author.

The first approach starts with a human need or design problem and then looks at how organisms or ecosystems in nature can solve that problem. This is a problem-oriented approach (top-down or design with biology in mind). This approach is effectively implemented by designers who, after identifying the initial goals and parameters of the design, look for solutions in the plant or animal world. The second approach is to identify interesting principles, behaviors, or functions in an organism or an ecosystem, and then look for a design problem that could be addressed. This is a solution-oriented approach (bottom-up or biology-influencing design). In this approach, knowledge of biology influences human design. It is managed by people with scientific knowledge who are looking for creatively relevant applications [3].

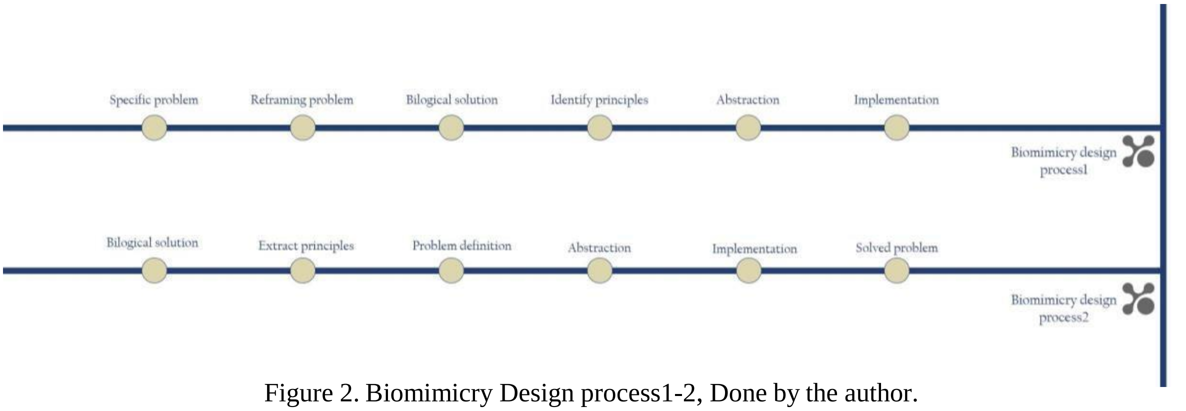


Figure 2. Biomimicry Design process1-2, Done by the author.

Biomimicry is still stuck with the exterior shape and ignores the operations that should happen inside the system. If we can call it the new age of biomimicry, with its complex in-between relationships and intersected layers, automation is the starting point that we need to focus on in order to create a continuous and homogeneous system.

Biomimicry started as a concrete concept that has been used from a superficial perspective, imitating a shape, does not mean that the last product will work as same as the natural element. There are a lot of layers that should be taken into consideration besides the shape, so we can call the process biomimetic. Abstraction and simplification gave this sensitive approach huge fame, what if we look at other layers, trying to reach out to the real complexity of the biological world, it will take humanity to another dimension.

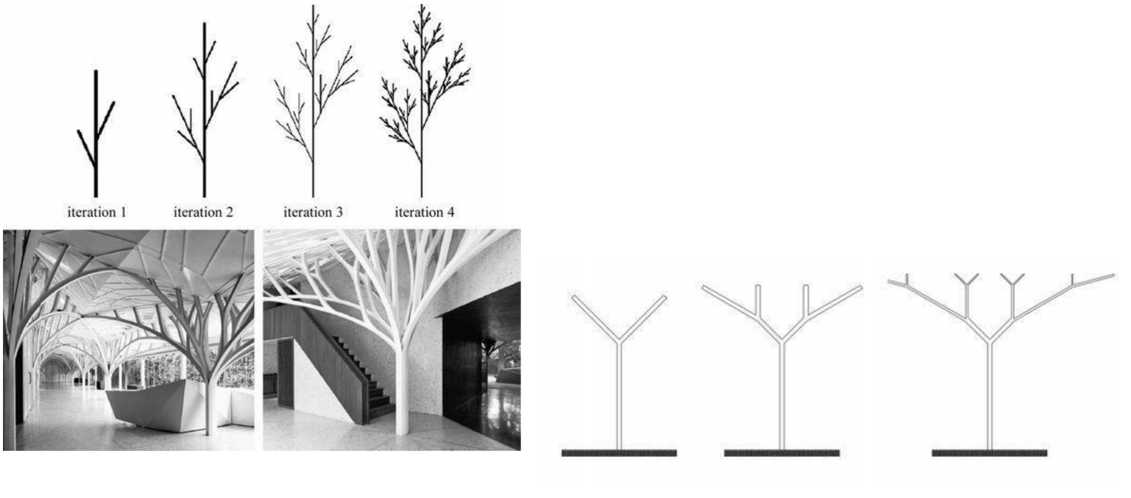


Figure 3. Biomimicry Initial thinking process, Above-fractal generation (plant growth) using L-System; below-the Tote Restaurant, Mumbai, designed by the Serie Architects, UK (Gawell, 2013).

2. BUILDINGS BASED ON COMPLEX SYSTEMS:

Biological models or natural phenomena can inspire architectural design at different levels; It can be divided into three levels: organism, behavior, and ecosystem. Within each of these three levels are five additional dimensions of imitation [4]. Design can be mimetic, for example in terms of what it looks like (what is the purpose of shape for the survival of an organism?), what it is made of (material composition), how it is made (construction process), how it works (performance), or what it is done (function). These five sub-levels are proposed by Maibritt Pedersen Zari to better facilitate the transfer from biology, especially into architectural design contexts [3].

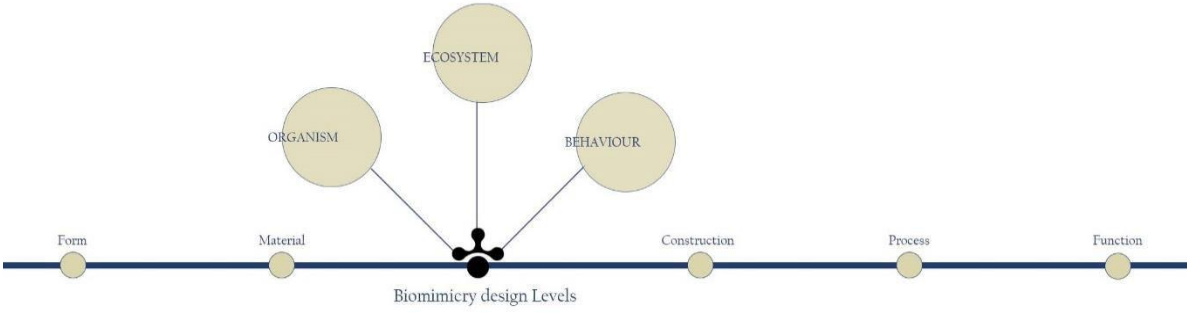


Figure 4. Biomimicry design levels and sub-levels, Done by the author.

If we can call it the new age of biomimicry, with its complex in-between relationships and intersected layers, automation is the starting point that we need to focus on in order to create a continuous and homogeneous system.
As there are some recent researches that say that the inside of the human body has its own light, there is no dark inside as we thought –because it is a closed body- but instead each part has its own specific type of light that helps to work in a proper way, so it is a good step to stop on and to rethink about the facades of our buildings by using environment-friendly materials to create that system, mainly using cellulose, pectin, or chitin that is biodegradable under demand looking to the microorganisms that they are a self-builder that have their natural genius fueling each other [8].

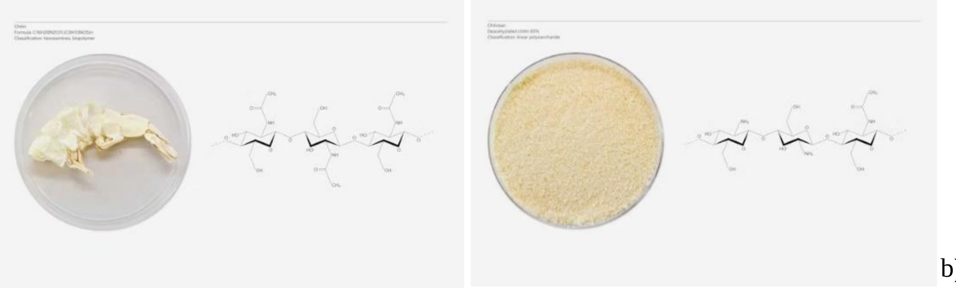
a)  b)

Figure 5. a) Shrimp-shell derived chitin b) Dried chitosan derived from chitin, Oxman projects.

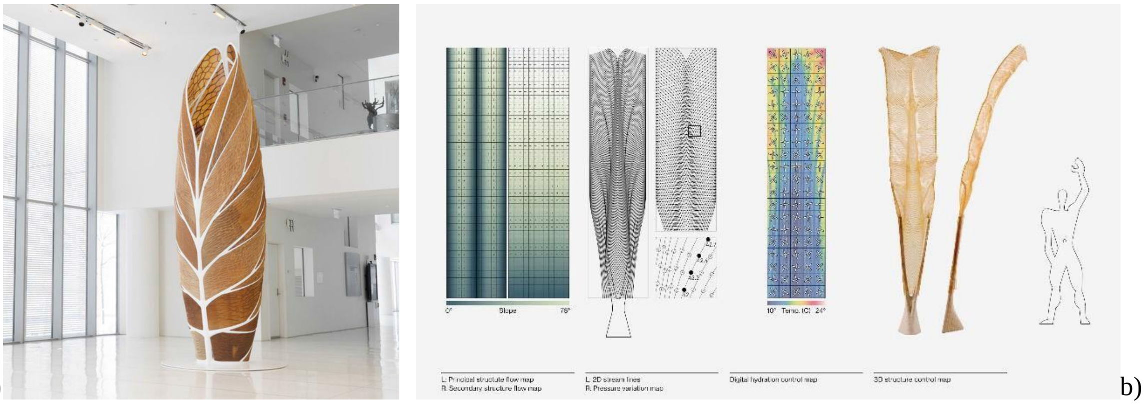
Natural biopolymers are produced by organisms such as shrimps, scrubs, and, butterflies, it is possible by using those biopolymers such as chitin to generate structures that are multifunctional out of a single part, by differentiating their chemical properties from dark to soft and transparent that are ready to use in printing structures with air bubbles inside contains photosynthetic microorganisms to capture carbon from the atmosphere and convert it into sugar. This is a big transition from beam to mesh on a big scale [5].
Working with microorganisms genius, water, and synthetic biology allows us to build an architecture that behaves like a tree.

2.1 Aguahoja Project:

The Aguahoja collection (pronounced agua-hocha) provides an alternative material to plastic by creating biopolymer composites with unique mechanical, optical, olfactory, and even gustatory qualities that can be adjusted, thus disrupting the harmful waste cycle. By utilizing the cycles of natural resources, these biocompatible and regenerative polymers can be materially engineered to decompose upon their return to Earth, so promoting new growth. With the utilization of plentiful natural resources, this concept envisions a future in which we disrupt the industrial cycle of overproduction and obsolescence. With this research, we hope to create materials from healthy ecosystems that can be temporarily extracted, used in human designs, and then returned to the environment to naturally degrade and support new growth. The goal is to create systems that encourage the preservation and enhancement of ecosystems while providing new opportunities for human creativity and production through the use of biopolymers in digital design and manufacturing [5].

Over time, with the evaporation of water, the pavilion's skin-shell bond transforms from a flexible and relatively weak system to a rigid system capable of responding to heat and humidity. Upon exposure to rainwater, the pavilion's skin and envelope will automatically degrade, restoring its components to the existing ecosystem and expanding the natural resource cycles that enabled their synthesis.

The pavilion's overall strength and stiffness—which include skin- and shell-like elements—are intended to endure shifting weather conditions, like heat and humidity, without sacrificing its flexibility. The skin-and-shell combination of the pavilion changes over time as water evaporates, going from a flexible and generally weak system to a rigid one that can react to humidity and heat. The pavilion's skin and shell will break down programmatically when exposed to rainwater, returning their parts to the natural ecosystem and enhancing the cycles of natural resources that made their synthesis possible [5].

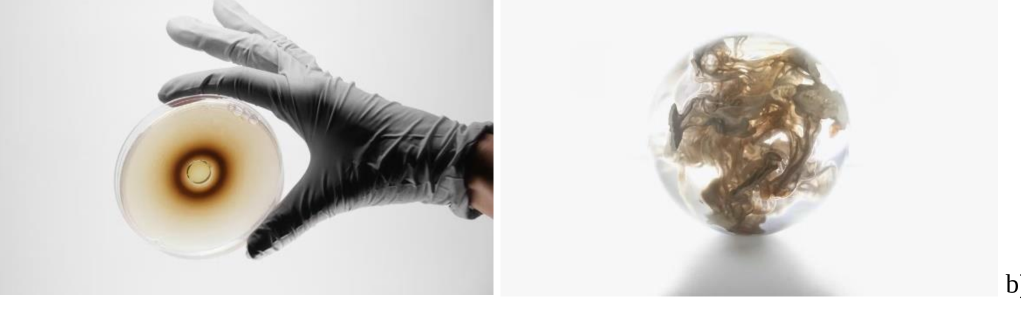


a) b)

Figure 6.a) The Aguahoja b) Structural venation pattern variations, Oxman projects.

2.2 Totems Project :

Biodiversity on planet Earth is under momentous threat, with extinction rates estimated at between 100 and 1,000 times their pre-human levels. The Mediated Matter Group has been in search of materials and chemical substances that can sustain and enhance biodiversity across living systems and has so far endured the perils of climate change. The naturally occurring chemical chain melanin, which gives all living things their pigmentation, is one such substance that can maintain and enhance biodiversity at the genetic, species, and ecosystem levels. Melanin can be synthesized by a reaction between an enzyme from a fungus called tyrosine and the protein building block L-tyrosine. The pigment can be extracted from bird feathers and squid ink, among others, and then purified and filtered in a series of steps. The genes for melanin production can also be incorporated into bacterial species such as Escherichia coli and thereby control space and time in response to changes in the environment. For example, its coloring could intensify when the sun is at its peak, protecting it from solar radiation [5] [6] .



a) b)

Figure 7.a) Microbial melanin synthesis b) Liquid pheomelanin (light) infusion into computationally grown and 3D printed channels , Oxman projects.

In the past year, a method has been developed for designing structures that can contain biological substances across scales (from micro to macro) and phases (solids and liquids). As part of the basic research behind totems, a series of spherical objects was created that feature a single connected channel filled with liquid melanin. These spheres exhibit a wide range of colors and absorption spectra, from light yellow to dark brown. At the same time, an architectural proposal for an environmentally friendly, melanin-enriched glass structure was developed. It is said to contain several types of melanin, naturally derived on-site and biologically synthesized in the laboratory. It provides UV protection during the day while still allowing for stargazing at sunset. The channels in these spheres have been computationally grown, 3D printed, and biologically expanded to create pockets for the liquid melanin, with channel diameters ranging from millimeters to centimeters. The installation examines the long and crucial interface between culture and nature by challenging the dichotomy between the societal and biological roles associated with designers' ability to manipulate melanin expressions within and between species. This inquiry, challenge our ongoing relationship with biology and natural history [5].

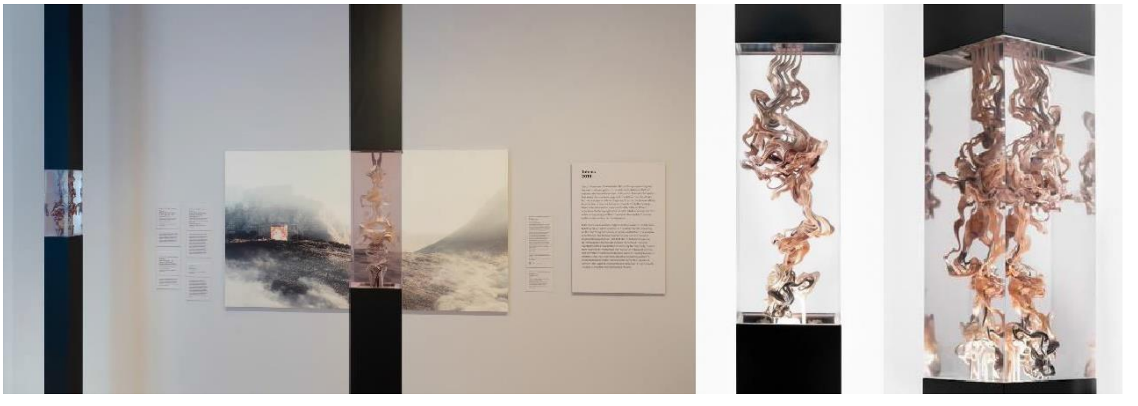


Figure 8. Channels and special pockets for melanin infusion range from mm to cm scale, Oxman projects.

Thinking about evolution by design and combining two or more micro-organisms that can work together to produce biophyls and growing them on a façade system according to the desired functionality that could repair damages, and sustain the façade going back always to nature [7]. Beyond architecture, it could be that we will need only a small wearable shell that can grow in a certain manner and at a specific speed, allowing us to benefit more from biomimicry. Art and fashion Are also keen on integrating the natural genius of a lot of microorganisms.

Figure 9. Biomorphic facades based on auto-growing, Barry Wark architect Biophilic biophilia design bio Houdini.

3. CONCLUSION:

Biomimicry is shifting. Before, it was about using nature for human needs. Now, it's moving towards deeper connections between species and ethics. This change is happening because of critical phenomenology. Even though biomimicry involves learning from nature, it's still mostly driven by human goals. Critics say biomimicry doesn't fully consider the connection between organisms and their surroundings. This goes deeper than just the materialistic approach. It's about how we relate to nature beyond just using it for our purposes.

Even with the advancement of AI and IT, the biological revolution is still happening. In the past, during the Industrial Revolution, it was simple to predict the future and that machines would rule. The tools available to designers to mold the built environment with a genuine understanding of what biology is and what it wants to become are the two biggest maps: nature and technology. It transports us back to a time when we were able to design alongside and for nature in harmony with technology.

ACKNOWLEDGMENTS:

This research received no external funding. The author declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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