

The Rise of Biodesign



Contemporary Research Methodologies
for Nature-Inspired Design in China

Edited by Mary Polites

Tongji University Press

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Preface

Bioinspired design is both simple and complex.

Simple as it provides an easy reference to discuss ideas through a means we all can relate and feel inspired by – *the natural world*. Nature easily engages those from a wide range of backgrounds, from environmental enthusiasts to professional designers and scientists, as well as the general public.

Complexity arises when we need to understand beyond what we see. At many levels, we are still exploring how natural systems are interrelated and how to start mapping these connections. Whether in science research or in design practice, interdisciplinary collaboration is one of the main paths to unlock the complexity of the natural world, and aim to successfully confront today's environmental challenges. Despite this, even nature-inspired fields are not immune to fragmentation, and the reason is well-known: scientific reductionism allows us to move faster. But do we know where we are heading? The biomimicry movement initiated by Janine Benyus two decades ago fused the principles of biomimetics with those of environmental awareness and ecological design. The statement was clear, we should continue learning from nature and aiming for innovation, but with a clear purpose: the preservation of our planet and the reconnection of the human species with the natural world.

In this context, the BiDL (Biomimetic Design Lab) was established as the first Biomimicry lab¹ in China in 2012, as part of the College of Design and Innovation (D&I) at Tongji University in Shanghai. The lab represented a merger between sustainability and contemporary design methods applied in a wide variety of fields, from architecture to industrial, interaction and service design.

¹ Biomimicry is defined by the Biomimicry Institute as the intended emulation of nature which focuses on the methods and concepts of study revolving around sustainability. BiDL lab fully recognizes other biomimetic labs in China having been established prior and includes them in this book to encompass the whole field of nature inspired design.

The BiDL is an unusual entity in the Chinese education environment, as courses associated with biomimicry or biodesign are typically reserved for master or expert level training. This means that specialized level education is made accessible for younger students, and opened to a variety of design degrees. Additionally, through the core sustainability classes, biomimicry is an integral topic for the undergraduate and graduate lectures.

This book has a double purpose: it celebrates the initial 5 years of BiDL, highlighting the efforts, challenges and achievements in education through a collection of students' work at the D&I, from undergraduate studios to master thesis.

And second, there was a strong interest to expand discussions about bioinspired design beyond the classroom, thus initiating conversations with other Chinese biomimetic labs² as a way of exchanging methodologies, sharing ambitions, and building collaborations.

This book offers unique insight into the current state of biomimetics and biomimicry in a challenging but exciting moment for bioinspired fields. Through professional research and students projects, this collection of work shines light on educational methods currently being explored in some of China's top institutions, as part of a national environmental agenda that is critical, not only for the future of the country, but for our entire planet.

² See Biomimicry Labs Map in pp. 20-25 for comparison.

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How to Read this Book

Chapter 1 is an extensive collection of perspectives curated from some of the earliest researchers in the field that have made biodesign what it is today. These interviews cover biomimetic design from all areas, biologists, zoologists, architects, and environmental designers. This chapter is for readers looking to discover the nuances of biomimetic design across many disciplines and is suited for practitioners as well as the general reader.

Chapters 2, 3, and 4 include works that provide examples of biomimetic design in practice. These chapters are well suited for researchers or students looking for information on current projects explored in China. Additionally, these texts have been developed so that a general audience can understand even the most scientific process.

Chapter 2 is an overview of the terms and concepts most used in the biomimetic projects found in chapter 3. This includes illustrations that break down patterns and unique aspects found in nature that are assumed by the biomimetic committee and often explored throughout the field.

Chapter 3 shows the research and outcomes by biomimetic and biomimicry labs from Jilin University, Beihang University, Donghua University and Tongji University.

Chapter 4 focuses on the design education methods covered at BiDL lab. These studies aim to show how students are introduced to topics of nature at the urban, human, and microscopic scale. These projects show how ideas were abstracted from natural logics and applied to design applications.

Chapter 5 offers a conclusion and perspective on the future of bioinspired design in China.

The final appendix provides a collection of references and educational tools that students and researchers may find useful.



Introduction

Bioinspiration is a broad field that encompasses many facets of biology, engineering and design. The research and development of materials, systems and techniques based on natural phenomena is considered one of the main contributors for innovation in applied sciences, and a critical driver for future advances in sustainability.

Bioinspiration is anticipated to have a significant contribution from the emerging markets in growing economies, such as India and China, and the byproducts from this field are estimated to greatly help towards the alleviation of world pollution in the next 20 years. However, the inspired-by-nature label does not necessarily imply a sustainable process, a waste-free outcome or an ecologically driven agenda. And that is how the biomimicry movement initiated by Janine Benyus in 1997 stood out among the rest of the biologically inspired fields.

In the last two decades, a growing number of biomimetic labs in China have been focusing on new approaches in the fields of material design, mechanics and engineering based on natural logics. However, the concept of biomimicry is still novel and abstract for many Chinese audiences. In this context, BiDL lab was established as one of the first centers to integrate sustainability, design and innovation within a Chinese university.

Leaf Veins

Detailed view of a leaf

The Rise of Bioinspiration

Although nature has been inspiring humankind in every possible field (science, art, design...) for thousands of years, there has been a cyclical interest in the natural world undeniable linked to historic environmental crisis caused by human activity. Today, due to a general awareness of global warming and its consequences, a renovated environmental concern has emerged since the beginning of the 21st century.

In addition, major technological breakthroughs experienced since the 1990s have allowed for unprecedented improvements in the measurement, analysis and understanding of any natural phenomena, including the simulation and prediction of environmental processes. Consequently, a closer relationship between nature and humankind is "in high demand" today, thus resulting into the widespread of nature-related fields in contemporary culture.

Despite the fact that bioinspiration has been recurrently present in scientific research since the 1950s, it was Janine Benyus' book, *Biomimicry: Innovation Inspired by Nature* (1997), a main trigger for the term to come out of the lab and dive into our daily life. In this regard, she managed to make the biomimicry movement stand out from previously established fields (biomimetics, bionics) by adding environmental awareness and sustainability to the inspired-by-nature equation.

Today, the concept of bioinspired design is developing at an impressive rate, and it is attractive enough to a wide audience. However, the extent to which bioinspiration can influence our lives through its different ramifications is still relatively unknown. In that sense, this book aims to serve as an introduction to the umbrella term of bioinspired design, and bring clarity to the field by explaining the similarities and dissimilarities between its different specializations.



Human Cities

D&I presented six projects that showcased approaches to social design, system design, open design, and strategic design, developing strategies for sustainability innovation.

History of Bioinspired Design

Besides the widespread recognition of Leonardo Da Vinci as the first modern bioinspired designer more than 500 years ago, the contemporary terms related to bioinspiration in design were developed halfway through the 20th century. The term biomimetics was coined by American biophysicist and polymath Otto Schmitt in the 1950s¹. It was used during his research on the Schmitt trigger, which studied the nerves in squid, attempting to engineer a device that replicated the biological system of nerve impulse propagation.² From then on, he continued to develop research focusing on technology that could mimic natural systems. In 1957, what was known as *biophysics* at that time (a branch of science concerned with the application of physical principles and methods to biological problems), was not sufficient in his view, and consequently, he developed the term biomimetics. Today, biomimetics as defined by the Merriam-Webster dictionary as the study of biological materials, structures, functions, mechanisms and processes, especially for the purpose of synthesizing similar products by artificial mechanisms which mimic natural ones.

The other term developed around the same period of time, and often used as synonymous with biomimetics, is bionics. The concept was coined by Jack Steele of the US Air Force in 1960 at a meeting at the Wright-Patterson Air Force Base.³ It most often suggests the combination of engineering and biology for technical end applications. Bionics appears to have more frequency of use in Europe and China, as shown in publication and lab titles, listed in the appendix. Bionics has been defined as a scientific discipline that "deals with the technical implementation and application of constructional processing and development principles of biological systems".⁴

1 Vincent, Julian F.v., Olga A. Bogatyreva, Nikolaj R. Bogatyrev, Adrian Bowyer, and Anja-Karina Pahl. "Biomimetics: Its Practice and Theory." *Journal of The Royal Society Interface* 3, no. 9 (2006): 471-82. doi:10.1098/rsif.2006.0127.

2 Harkness, Jon M. "In Appreciation: A Lifetime of Connections: Otto Herbert Schmitt, 1913 - 1998." *Physics in Perspective (PIP)* 4, no. 4 (2002): 456-90. doi:10.1007/s000160200005.

3 Gundlach, Carsten. "Bionics in Patents - Semantic Base Analysis for the Exploitation of Bionic Principles in Patents." In *Current Scientific and Industrial Reality: Proceedings of the TRIZ-Future Conference 2007*; Frankfurt, Germany, November, 6th - 8th, 2007. Kassel: Kassel Univ. Press, 2007.

4 Harkness, Jon M.

On the other hand, biomimicry, coined by Janine Benyus in 1997, is part of a general trend of convergence between biology, engineering, and sustainability.⁵ The meaning associated with biomimicry is *good design abstracted from nature*. The definition, however, according to the Merriam-Webster Dictionary, references directly to biomimetics and defines it as the imitation of natural biological designs or processes in engineering or invention. This does not convey all social and environmental implications that reference the sustainable and holistic ethos. In that sense, the Biomimicry Institutes's definition as "an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies" more accurately describes the agenda behind the term.

In an attempt to differentiate between the three concepts, we could suggest that:

- biomimetics aims to replicate organic and inorganic structures, logics and processes found in nature, to solve existing problems or to find new applications;
- bionics focuses on the study of biological systems and the generation of artificial counterparts of those entities that could perform in a similar or improved manner for different purposes;
- biomimicry learns from nature to reproduce materials, objects, processes and methods that come together with an idea of aiming towards social, economic and environmental sustainability.

In the context of this book, we will assume that the portions focusing on the scientific aspects of biological design can be considered biomimetics or bionics, while in the areas that focus on sustainability, the term biomimicry will be used. Also, to put some emphasis on the similarities among all the bioinspired design fields, the following time line traces the origin and current state of all related terms through seminal books and key figures in the fields of science, literature, art and design.

⁵ Yoram, Helfman Cohen Yael. Reich. *Biomimetic Design Method for Innovation And Sustainability*. S.I.: Springer, 2018.



