

Comparative Analysis of Nature-Inspired Strategies in Building Engineering: A Multilevel Biomimicry Perspective

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Abstract- This study investigates the integration of biological strategies into building systems and engineering through a multilevel biomimicry perspective. A systematic evaluation framework is established, categorizing biomimicry into two approaches (problem-oriented and solution-oriented), three levels (organism, behavior, and ecosystem), and five imitation dimensions: form, material, construction, process, and function. The research focuses on the 'maturity period' of biomimetic architecture, analyzing landmark projects that fundamentally established the transition from formal imitation to functional and systemic biomimicry. Fifteen diverse building examples were selected globally based on their prominence in the literature and their role as pioneering prototypes representing different climatic regions. The methodology examines how these specific dimensions—particularly material and construction—contribute to structural efficiency and sustainability goals. Quantitative findings reveal that 60% of the cases adopted a problem-oriented approach, reflecting a prevailing tendency to solve specific design challenges through natural strategies. While organism-level applications are more frequent due to their relative simplicity in form-based imitation, the study indicates that the ecosystem level theoretically holds the highest potential for promoting holistic sustainability and complex system integration. Furthermore, the analysis suggests that moving beyond aesthetics to integrate 'construction' and 'process' dimensions—such as adaptive mechanisms—presents a comprehensive conceptual framework for supporting technical efficiency and environmental compatibility. These findings highlight biomimicry's potential as a robust baseline for innovative building engineering, providing a taxonomic foundation for future research in computational design and sustainable structures.

Keywords- Bio-inspired Materials, Nature-Based Solutions, Adaptive Systems, Sustainable Construction, Building Engineering.

Yapı Mühendisliğinde Doğadan Esinlenen Stratejilerin Karşılaştırmalı Analizi: Çok Seviyeli Bir Biyomimikri Perspektifi

Öz- Bu çalışma, biyolojik mekanizmaların yapı sistemleri ve mühendisliğine entegrasyonunu çok seviyeli bir biyomimikri perspektifi üzerinden incelemektedir. Biyomimikriyi iki yaklaşım (problem odaklı ve çözüm odaklı), üç seviye (organizma, davranış ve ekosistem) ve beş taklit boyutu (biçim, malzeme, yapım, süreç ve fonksiyon) şeklinde kategorize eden sistematik bir değerlendirme çerçevesi oluşturulmuştur. Araştırma, biyomimetik mimarinin “olgunluk dönemine” odaklanarak, biçimsel taklitten fonksiyonel ve sistem odaklı biyomimikriye geçişi temelden sağlayan dönüm noktası niteliğindeki projeleri analiz etmektedir. Literatürdeki önemleri ve farklı iklim bölgelerini temsil eden öncü prototipler olmaları nedeniyle dünya genelinden on beş farklı yapı örneği seçilmiştir. Uygulanan yöntem, özellikle malzeme ve yapım gibi belirli boyutların yapısal verimlilik ve sürdürülebilirlik hedeflerine nasıl katkıda bulunduğunu incelemektedir. Nicel bulgular, vakaların %60'ının problem odaklı bir yaklaşım benimsediğini ve bu durumun belirli tasarım zorluklarını doğal stratejilerle çözmeye yönelik yaygın bir eğilimi yansıttığını ortaya koymaktadır. Organizma seviyesindeki uygulamalar, biçim temelli taklit kolaylığı nedeniyle daha yaygın olsa da çalışma, bütüncül sürdürülebilirliği ve karmaşık sistem entegrasyonunu teşvik etmede ekosistem seviyesinin teorik olarak en yüksek potansiyele sahip olduğuna işaret etmektedir. Ayrıca analizler, estetiğin ötesine geçerek adaptif mekanizmalar gibi 'yapım' ve 'süreç' boyutlarını entegre etmenin, teknik verimliliği ve çevresel uyumluluğu destekleyen kavramsal bir çerçeve sunduğunu göstermektedir. Bu bulgular, biyomimikrinin yenilikçi yapı mühendisliği için güçlü bir teorik altyapı sunma

potansiyelini vurgulayarak, hesaplamalı tasarım ve sürdürülebilir yapılar alanındaki gelecek araştırmalar için taksonomik bir temel sağlamaktadır.

Anahtar Kelimeler- Biyomimetik Malzemeler, Doğa Temelli Çözümler, Adaptif Sistemler, Sürdürülebilir Yapım Sistemleri, Yapı Mühendisliği.

1. Introduction

The fundamental human drive to secure shelter, sustenance, and safety from environmental stressors has historically required a comprehensive interpretation of the natural world. In response to these survival needs, natural formations have been systematically observed and replicated, providing inspiration grounded in both organic and inorganic systems [1, 2]. Nature operates as a profound instructional guide for the building design process [3], and systematic observation confirms its essential role in defining modern design concepts [4]. Consequently, the biomimetic translation of natural systems has led to a significant conceptual diversification in design outcomes [5]. By integrating natural responses to specific environmental challenges into the architectural domain, strategic pathways can be theoretically established to address complex structural problems [6].

Humanity's historical reliance on nature for survival eventually catalyzed the formal methodologies now recognized as biomimicry [3, 7]. This discipline focuses on the systematic imitation of nature, involving the translation of biological logic into human design workflows [8]. Such an approach seeks to conceptualize sustainable solutions by learning from living organisms and broader ecosystems [9, 10]. These natural problem-solving mechanisms prompt engineers and designers to incorporate biological intelligence directly into architectural practice [11]. In this context, biomimicry provides a robust framework for conceptualizing designs that mirror adaptive solutions refined over extensive evolutionary periods [12, 13, 14]. Given the current challenges of resource depletion and environmental instability, biomimicry indicates a strategic pathway for conceptualizing buildings that exist in closer harmony with the natural environment [15, 16]. Applying natural principles of equilibrium and longevity to building design theoretically supports the development of environmentally compatible structures [17]. Ultimately, the various levels of biological life—organisms, behaviors, and ecosystems—provide a foundational taxonomic toolkit for sustainable innovation [18].

While nature-inspired practices are increasingly central to modern sustainable design [19], a comprehensive evaluation remains scarce regarding how building strategies integrate with the structural traits and behavioral dynamics of specific organisms [20]. Currently, most applications focus heavily on the organism and behavior levels, often at the expense of ecosystem-scale integrity [12, 18]. This research addresses the taxonomic execution of biomimicry within the building design process [21]. The investigation focuses on how these practices are shaped by the relationships between organisms and their environments, how such relationships are conceptually translated into built forms, and the specific sustainability potentials theoretically associated with each level.

The underlying premise of this study is that biological characteristics directly inform architectural form, and that holistic ecosystem modeling theoretically holds a high potential for comprehensive sustainability compared to fragmented approaches [22, 23]. Beyond aesthetic or formal inspiration, biomimetic strategies present a conceptual framework for minimizing the environmental footprint of buildings, supporting theoretical improvements in energy efficiency and climate resilience [24, 25, 26]. Advancing sustainable architecture through organism, behavior, and ecosystem-level mimicry indicates strategic pathways for dynamic adaptation across the building lifecycle [8, 12].

Within this operational framework, nature-inspired architectural strategies generally progress through two distinct epistemological tracks: the problem-oriented (top-down) approach and the solution-oriented (bottom-up) approach. The problem-oriented methodology initiates directly within the human domain to address a concrete design vulnerability or technical challenge. In this track, the designer first explicitly delineates an architectural problem (e.g., "How can a building envelope be cooled effectively through passive natural principles?") and subsequently investigates biological domains to decode and replicate corresponding natural mechanisms. Conversely, the solution-oriented methodology originates directly within the biological domain, beginning with a specific scientific or organismic discovery (e.g., analyzing how the microscopic surface topography of a lotus leaf minimizes water and dirt adhesion to exhibit self-cleaning properties). This structural logic is then systematically scaled up and translated into functional building engineering concepts, such as adaptive, self-cleaning facade coatings [27, 28].

This study establishes a taxonomic baseline for biomimetic architecture by defining core concepts and examining how biological strategies translate into building design. To achieve this, fifteen pioneering prototypes from around the globe are classified within a conceptual framework to identify specific biological inspirations and their projected contributions to sustainability. The analysis emphasizes the necessity of moving beyond visual mimicry to evaluate design strategies across organismal, behavioral, and ecosystem scales. While biomimicry represents a valuable conceptual instrument for multiple disciplines, including engineering and environmental sciences, this research focuses strictly on its taxonomic application in architectural project development. Impact assessments or physical performance measurements in other specialized engineering fields remain outside the current scope.

2. Materials & Methods; Evaluation of Biomimicry Applications

A comprehensive taxonomic framework consisting of specific evaluation criteria was established to examine how biomimicry practices manifest in building designs and theoretically support sustainability goals. Several parameters for the sample analyses were identified and grouped under three main categories (see Figure 1). The first category refers to approaches to biomimicry in design, which are fundamentally divided into two methodologies: problem-oriented and solution-oriented. The second category focuses on biomimicry levels, categorized into three distinct groups: organism, behavior, and ecosystem. Within this framework, the third category—biomimicry imitation dimensions—is considered a subsystem of these levels. These dimensions consist of five key elements: form, material, construction, process, and function.

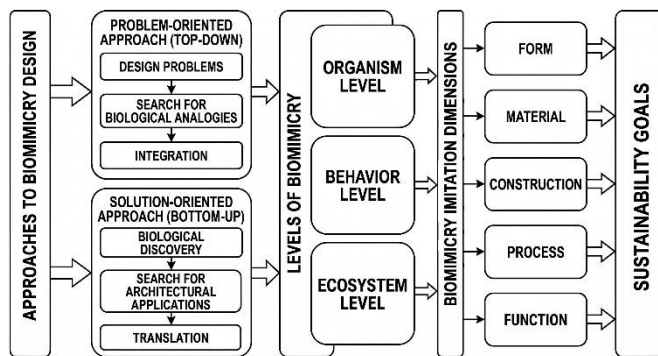


Figure 1: Parameters for evaluating biomimicry applications.

The methodology follows a three-stage execution process. First, biomimetic design approaches are examined to define both problem-oriented (top-down) and solution-oriented (bottom-up) methodologies. The study then delineates the application areas for biomimicry at the organism, behavior, and ecosystem levels to evaluate their specific conceptual effects on building design. Finally, the functioning of biomimicry imitation dimensions—including form, material, construction, process, and function—is explored to analyze their theoretical impact on structural and environmental performance.

To ensure methodological transparency, the selection of the fifteen pioneering prototypes was conducted based on clear, systematic parameters: literature prominence, foundational status, representation of diverse functional typologies, and a systematic, reproducible categorization across various climatic zones utilizing the Köppen-Geiger climate classification system. Furthermore, it is important to clarify that this framework does not measure physical, empirical, or real-world sensor performance. Because the primary objective of this comparative analysis is to evaluate the conceptual development, biomimetic design logic, and taxonomic translation during the designated maturation era (2000–2015), the physical construction status of a project—whether built, unbuilt, removed, or under construction—does not compromise its theoretical validity or structural relevance within this taxonomic baseline.

2.1 Approaches to Biomimicry in Design

Biomimetic design strategies are fundamentally categorized into two primary methodologies: the problem-oriented approach and the solution-oriented approach. The problem-oriented approach, often recognized as a "top-down" strategy, aims to identify specific human needs or design challenges and subsequently observe how corresponding organisms or ecosystems address them. This method enables the analysis of natural problem-solving techniques and the integration of evolved biological mechanisms to mitigate environmental stresses in human-made systems [6, 12, 29].

Conversely, the solution-oriented approach, or "bottom-up" strategy, begins by identifying a specific biological discovery—such as a unique organismal characteristic, behavior, or function—which is then translated into a technical design framework [12, 20, 30]. While both methods aim to utilize nature's time-tested pathways to address environmental challenges [6], the solution-oriented process is specifically driven by biological inspiration rather than pre-defined design constraints. Rather than directly replicating natural configurations, this process focuses on developing functional solutions targeted at the design challenge [12], fostering the conceptualization of frameworks that offer unique operational advantages derived from the biological world [4, 31].

Beyond these primary methodologies, supplementary classifications exist within building discourse. Systematic observations by Mazzoleni (2013) on how animals adapt to different environmental conditions led to the categorization of potential building applications into four functional areas: communication, thermoregulation, water regulation, and protection. Although diverse in their focus, all these approaches emphasize the strategic transfer of biological intelligence into sustainable building engineering practice.

2.2 Biomimicry Levels in Design

Biomimicry levels represent the extent of biological imitation, aiming to utilize natural design principles as a primary source of inspiration. The objective is not the exact replication of a form, process, or ecosystem; rather, the underlying principles of a natural model are analyzed to conceptually inform the design phase [10]. This technical knowledge allows designers to determine how to systematically mimic both living and non-living entities. Three primary levels are identified within the literature: organism, behavior, and ecosystem [11, 12, 22]. Together, these levels provide a framework that guides design workflows and conceptually supports the development of sustainable architectural solutions.

The organism level involves directly mimicking entities found in nature—such as plants or animals—either partially or as a whole. At this initial stage, inspiration is drawn from formal potential [9, 17], facilitating the replication of morphological traits like shape, components, or materials observed in the wild [18]. Biomimicry at this scale refers to conceptualizing human-made systems that mirror the structural or functional characteristics of these biological references.

The behavior level centers on mimicking natural biological processes or operational functions [7, 10]. This level moves beyond simple formal copying to explore how organisms interact with their surroundings and execute specific tasks. The dynamics of natural processes and their resulting outputs are analyzed to understand how these actions are implemented. While Pawlyn highlights the direct imitation of natural processes, Zari (2007) defines this level as mimicking specific behaviors or the objects associated with them.

The ecosystem level represents a highly advanced stage, focusing on natural ecosystems as a whole [7]. It seeks to replicate entire systems and their internal functions [24], aiming to sustain the complex relationships between organisms and their environments [12]. This process is highly intricate and theoretically presents significant challenges for implementation [10]. At this scale, the maintenance of balance among diverse organisms is essential, typically addressing larger urban or regional contexts.

Zari (2007) classifies each biomimicry level into five core dimensions: form, material, construction, process, and function. While interpretations vary, these categories provide a unifying framework for translating biological mechanisms into technical design. Form relates to external geometry; material involves adopting physical or chemical attributes; and construction reflects biological building techniques. Process mimics natural flows of energy or matter, while

function replicates purpose-driven natural mechanisms to serve human requirements. Together, these dimensions expand the scope of biomimicry and promote a more integrated, holistic relationship between engineering and the natural world.

3. Comparative Analysis of Nature-Inspired Building Design

In architectural practice, biomimicry provides a conceptual framework for conceptualizing innovative, sustainable designs modeled after natural systems at organismal, behavioral, and ecosystem scales. This section assesses specific case studies to illustrate how various biomimetic approaches and dimensions theoretically manifest in building design (Table 1). A comparative case study methodology was employed to investigate biological inspiration, conceptual design outcomes, and projected sustainability potentials. Evaluations are structured around three main parameters established in the methodology, covering fifteen global building examples to analyze the conceptual integration of biomimicry into sustainable practice. To ensure clarity and systematic legibility across these analytical frameworks, specific taxonomy alphanumeric codes are introduced, where "O" denotes the organism level (O1–O5), "B" denotes the behavior level (B1–B5), and "E" denotes the ecosystem level (E1–E5).

Table 1: Classification of selected sample projects according to biomimicry levels and imitation dimensions (Note: O denotes Organism, B denotes Behavior, E denotes Ecosystem).

Levels of Biomimicry						
Imitation Dimension	Organism (O)		Behavior (B)		Ecosystem (E)	
Form	O1	Qatar National Conven. Center	B1	Orquideorama	E1	Zira Island
Material	O2	ZCB Bamboo Pavilion	B2	Hy-Fi Tower	E2	The Eden Project
Construction	O3	Milwaukee Art Museum	B3	Beijing Stadium	E3	Coral Reef Project
Process	O4	Gherkin Tower	B4	HygroSkin	E4	California Sc Academy Museum
Function	O5	Supertree Grove	B5	Council House 2	E5	Masdar City

The case selection rationale is explicitly transparent, framing the selection of the fifteen pioneering prototypes based on clear, systematic parameters: literature prominence, foundational status, representation of diverse functional typologies, and a systematic categorization across various climatic zones via the Köppen-Geiger climate classification system to categorize sites by temperature and precipitation [32]. During the case selection process, academic databases (such as Scopus and Web of Science) and architectural repositories were systematically searched using keywords including 'biomimicry in architecture,' 'bio-inspired building,' and 'adaptive facades.' Inclusion criteria were strictly limited to pioneering projects designed or constructed between 2000 and 2015 that explicitly utilized biological analogies, while projects lacking verifiable technical documentation or falling outside this designated 'maturation era' were excluded. The coding logic is presented as a reproducible, rule-based classification framework.

Although biomimicry emerged as a distinct concept in the late 1990s, the starting year for this study was set as 2000. To maintain a manageable sample of fifteen projects, the upper limit of the analysis was set at 2015. This timeframe represents

a critical 'maturation era' for biomimetic architecture, featuring pioneering projects that defined the conceptual transition from purely formal imitation toward functional and systemic applications. These foundational prototypes offer a stable taxonomic baseline for examining nature-inspired engineering strategies. Figure 2 provides a chronological list of these projects categorized by level and dimension.

Technical data and visual records for the chronological analysis (Figure 2) were gathered from various scholarly and digital archives. Visual data for projects O1–O5, B1–B5, and E1–E5 were sourced from established building engineering references [15, 16, 23, 33–44]. Construction dates and design specifications were also verified through multiple academic and professional sources [2, 34, 38–41, 45–50]. The analysis indicates that organism-level examples cover the widest span (2001–2015), while behavior (2006–2014) and ecosystem (2000–2011) levels are more concentrated temporally.

To ensure methodological transparency and a systematic evaluation, a building identity table (Table 2) was developed detailing the status, designer, function, height, and climatic context for each example. These data were then consolidated into level-specific analysis tables (Appendices A, B, and C) to

allow for a direct comparison of construction timelines and theoretical sustainability potentials. Within this framework, it is important to clarify that this study does not measure physical, empirical, or real-world sensor performance. Because the primary objective of this comparative analysis is to evaluate the conceptual development, biomimetic design logic, and taxonomic translation during the designated maturation era (2000–2015), the physical construction status of a project—whether built, unbuilt, removed, or under construction—does not compromise its theoretical validity or structural relevance within this taxonomic baseline.

Final evaluations for the organism level (See: Appendix A, Table A1), behavior level (See: Appendix B, Table B1), and ecosystem level (See: Appendix C, Table C1) draw from diverse data sources for a thorough analysis of conceptual design strategies. Visual and technical assessments were cross-referenced with several key references [19, 34, 38-42, 45, 47, 51-65]. These consolidated tables provide the necessary classification to examine both design methodologies and projected sustainability potentials based on the established criteria.

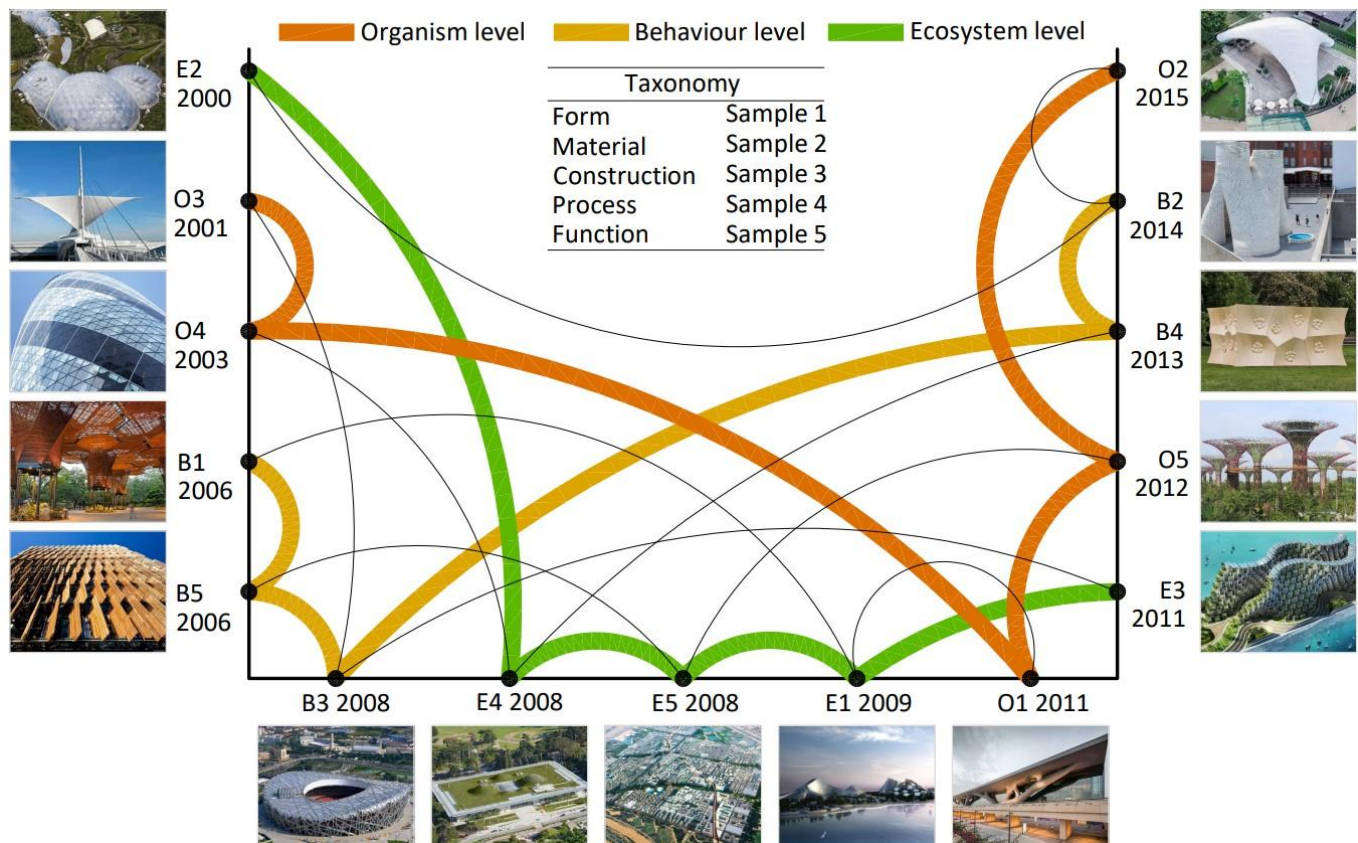


Figure 2: Chronological analysis of sample projects according to biomimicry levels [2, 15, 16, 23, 33-65].

Table 2: Information included in the building identity table.

Building Features		Biomimicry Features	
Status	Design / Constr. year	Inspired Feature	Determinant Feature
Year	Architect	Biomimicry Level	Imitation Method
Location	Function	Application Area	Sustainability Contribution
Climate	Height (m)		

4. Findings

The chronological mapping of the sample projects, categorized by biomimicry level, reveals distinct trends in temporal distribution and design complexity. Organism-level applications span the widest time period (2001–2015), indicating sustained interest and theoretical feasibility for integrating morphological or material inspirations. Behavior-level projects cluster between 2006 and 2008, suggesting a

period of concentrated focus on conceptually adaptive systems. Ecosystem-level projects predominantly emerged between 2008 and 2011, reflecting an interest in systemic sustainability, although higher implementation complexity has left several proposed projects unbuilt. The year 2008 appears as a pivotal point where all three biomimicry levels are represented, indicating a surge in interdisciplinary design experimentation. While ecosystem-level biomimicry theoretically holds a high potential for comprehensive sustainability, organism-level strategies remain dominant due to their relative taxonomic simplicity. Figure 3 depicts the temporal distribution of these trends in the Bubble Chart of Biomimicry Projects.

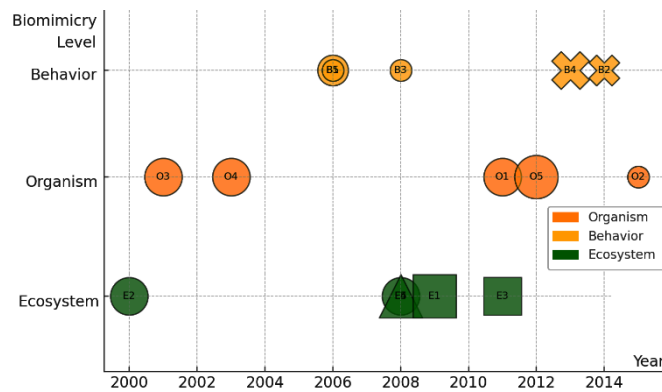


Figure 3: Bubble chart of biomimicry projects by year, and level.

A Radar Chart (Figure 4) was developed to compare the intensity of five core design parameters—form, material, construction, process, and function—illustrating how biomimicry levels conceptually engage with different imitation dimensions. The analysis indicates that organism-level applications focus heavily on form and material, reflecting morphological mimicry. Behavior-level examples demonstrate more activity in the process and function domains, aligning with interactional strategies and adaptive methodologies. Ecosystem-level projects exhibit the strongest engagement with function and process, pointing to a conceptual integration of systemic operations into building design. This visualization indicates that each level prioritizes distinct theoretical strategies based on inherent structural complexity.

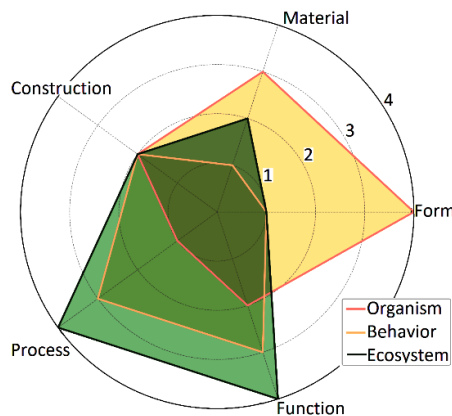


Figure 4: Biomimicry levels by imitation dimensions.

The comparative analysis highlights both thematic continuity and structural diversity across the fifteen cases. Projects at the organism level largely utilize a solution-oriented approach, focusing on form, material, or construction inspired by specific flora and fauna. Behavior-level examples integrate conceptually responsive systems, such as adaptive façades, which highlight dynamic interpretations and frequently employ problem-oriented strategies. Ecosystem-level studies, although less frequently realized as built structures, suggest a broader theoretical scope of sustainability by conceptually incorporating urban-scale water, waste, and energy management methodologies. The ecosystem level indicates a significant concentration of systems thinking, even though it presents substantial complexity for real-world implementation. Within this comparative framework, it is crucial to emphasize that because the primary objective is to evaluate the conceptual development, biomimetic design logic, and taxonomic translation during the designated maturation era (2000–2015), the physical construction status of a project—whether built, unbuilt, removed, or under construction—does not compromise its theoretical and structural validity.

A consistent conceptual emphasis on environmental integration and theoretical energy efficiency is apparent across all levels, as summarized in Table 3. This layered comparison illustrates how biomimicry provides a taxonomic framework for conceptualizing functional sustainability and aesthetic innovation across architectural scales.

Table 3: Comparative summary of biomimicry applications by design level.

Biomimicry Level	Built Projects	Unbuilt / Removed Projects	Dominant Imitation Method	Typical Inspiration Focus	Common Sustainability Themes	Application Complexity
Organism	5	0	Solution-Oriented	Form / Material	Energy Efficiency, Solar/Wind Control, Water Management	Low
Behavior	3	2	Mixed	Adaptive Systems	Ventilation, HVAC, Zero Carbon, Structure Efficiency	Medium
Ecosystem	2	3	Problem-Oriented	Urban Systems	Energy & Waste Management, Flexible Design, Ecosystem Integration	High

5. Conclusion

This research indicates that architectural biomimicry represents a rigorous conceptual engineering framework for theorizing operational efficiency rather than mere formal replication. By evaluating fifteen pioneering prototypes within the 2000–2015 'maturation era', a taxonomic baseline for nature-inspired engineering methodologies has been established. The diversity observed in these cases—ranging from the 3-meter HygroSkin to the 180-meter Gherkin Tower—suggests that translated biological principles remain scale-independent and functionally versatile across varied climatic zones.

The findings provide conceptual support for the initial hypothesis. While structural and behavioral mimicry frequently dictates building form—evident in the high frequency of organism-level applications—holistic ecosystem modeling theoretically presents the highest potential for comprehensive sustainability gains. The generated data indicates that 60% of the analyzed cases utilized a problem-oriented methodology, signaling a potential shift toward proactive engineering design rather than passive aesthetic inspiration. To conceptualize a higher degree of circularity in the built environment, future practices indicate a need to transition from individual organism mimicry toward systemic ecosystem modeling.

The technical dimensions of 'material' and 'construction' appear equally vital to this evolutionary paradigm. These pioneering prototypes bypass the 'render trap' of purely digital aesthetics, illustrating how bio-inspired fabrication methods can foster regional material compatibility and innovative assembly techniques. Although the 'functional' dimension introduces significant implementation complexity, it presents a comprehensive conceptual framework for supporting theoretical efficiency regarding energy performance and adaptive capabilities. Within this comparative baseline, it is crucial to reiterate that because the primary objective is to evaluate conceptual development and biomimetic design logic during the designated maturation era (2000–2015), the physical construction status of a project—whether built, unbuilt, removed, or under construction—does not compromise its theoretical and structural validity.

The proposed five-dimensional analysis matrix serves as a systematic baseline for engineers, architects, and urban planners. These pioneering prototypes provide the theoretical grounding necessary for bio-fabrication and computational workflows to advance. Future efforts indicate strategic pathways to move from descriptive taxonomic analysis to performance-based simulation, leveraging digital design tools to map complex ecosystem interdependencies. Substantive progress in this field will ultimately benefit from empirical post-occupancy evaluations to capture real-world operational data, ensuring the long-term viability of biomimetic methodologies in the built environment.

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However, the authors maintain full responsibility for the content of the manuscript. The core scientific substance—including the theoretical framework, data collection methodology, technical audit of the fifteen architectural projects, and final scholarly interpretation—was developed exclusively by the authors. All AI-aided suggestions were critically reviewed, manually edited, and validated to preserve technical accuracy and academic integrity.

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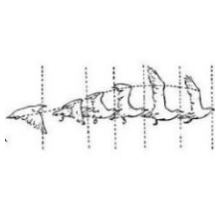
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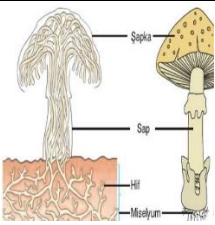
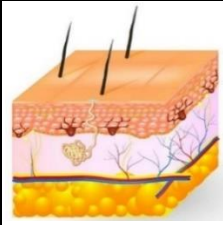
Appendix A.

Table A1: Analysis of biomimicry case studies at the organism level (The table is reproduced from the first author's thesis) [33-37, 45, 46, 48, 51-55, 61, 62].

Building Name	O1	O2	O3	O4	O5
	Qatar National Convent. Center	ZCB Bamboo Pavilion	Milwaukee Art Museum	Gherkin Tower	Supertree Grove
Inspired by					
Sample Building					
Status	Built-up	Built-up	Built-up	Built-up	Built-up
Year-Location	2011 - Qatar	2015 – Hong Kong	2001 - USA	2003 - London	2012 - Singapore
Climate Zone	Hot Desert Climate	Humid Subtropical Climate	Humid Continental Climate	Temperate Oceanic Climate	Tropical Rain Climate
Function	Convention Center	Pavilion	Museum	Office	Botanical Garden
Level	Organism Form	Organism Material	Organism Construction	Organism Process	Organism Function
Imitation Method	Solution-Oriented Approach	Solution-Oriented Approach	Solution-Oriented Approach	Problem-Oriented Approach	Problem-Oriented Approach
Notes	The trunk of the Sidra tree, a local plant species, inspired the use of fewer vertical supports in the eaves design.	The natural structure of the bamboo plant served as inspiration for the selection of the primary structural material.	Inspired by the bird's takeoff process, a durable and lightweight design was created using steel elements.	Inspired by the Venus flower glass sponge, the floors were arranged to enhance daylight intake and improve energy efficiency.	The photosynthesis mechanism of trees has served as inspiration for vertical gardens, water storage, and energy systems.
Sustainability Contribution	✓ Energy Efficiency ✓ Water Management ✓ Use of Natural Resources	✓ Use of Natural Resources	✓ Structure ✓ Solar Control ✓ Wind Control	✓ Indoor Lighting ✓ Indoor Ventilation	✓ Design ✓ Solar Control ✓ Wind Control ✓ Water Management

Appendix B.

Table B1: Analysis of biomimicry case studies at the behavior level (The table is reproduced from the first author's thesis) [23, 38, 39, 43, 44, 47, 56-58, 63].

Building Name	B1	B2	B3	B4	B5
	Orquideorama	Hy- Fi Tower	Beijing Stadium	HygroSkin	City Council House 2
Inspired by					
Sample Building					
Status	Built-up	Removed building	Built-up	Removed building	Built-up
Year-Location	2006 - Medellin	2014 – New York	2008 - Beijing	2013 - France	2006 - Australia
Climate Zone	Tropical Monsoon Climate	Humid Continental Climate	Humid Continen. Climate with Hot Summers	Temperate Oceanic Climate	Temperate Oceanic Climate
Function	Botanical Garden	Pavilion	Stadium	Pavilion	Office
Level	Behavior Form	Behavior Material	Behavior Construction	Behavior Process	Behavior Function
Imitation Method	Solution-Oriented Approach	Solution-Oriented Approach	Problem-Oriented Approach	Problem-Oriented Approach	Problem-Oriented Approach
Notes	The hexagonal geometry of a honeycomb has served as an inspiration for determining the design form.	The organic structure of mushrooms has inspired the design of biobricks that contribute to the carbon cycle.	Inspired by bird nests, a durable and lightweight design was created using steel elements.	The moisture-responsive movement of pine cones inspired the design of an adaptive façade sensitive to relative humidity.	The respiration mechanism of mammal skin inspired the design of an active façade that regulates temperature differences.
Sustainability Contribution	✓ Energy Efficiency ✓ Aesthetics	✓ Zero Carbon ✓ Energy Efficiency	✓ Structure	✓ Indoor Lighting ✓ Energy Efficiency ✓ HVAC (Heating, Ventilation, and Air Conditioning)	✓ Ventilation

Appendix C.

Table C1: Analysis of biomimicry case studies at the ecosystem level (The table is reproduced from the first author's thesis) [40-42, 49, 50, 59, 60, 64, 65].

Building Name	E1	E2	E3	E4	E5
	Zira Island	The Eden	Coral Reef Project	California Scien. Academ. Museum	Masdar City
Inspired by	No visual data.			No visual data.	No visual data.
Sample Building					
Status	Unbuilt project	Built-up	Unbuilt project	Built-up	Under construction
Year-Location	2009- Azerbaijan	2000 – UK	2011 - Haiti	2008- California	2008 - Abu Dhabi
Climate Zone	Warm Steppe Climate	Temperate Oceanic Climate	Equatorial Rain Climate	Temperate Mediterranean Climate	Hot Desert Climate
Function	Mixed Use	Botanical Garden	Mixed Use	Museum	Mixed Use
Level	Ecosystem Form	Ecosystem Material	Ecosystem Construction	Ecosystem Process	Ecosystem Function
Imitation Method	Problem-Oriented Approach	Problem-Oriented Approach	Solution-Oriented Approach	Problem-Oriented Approach	Problem-Oriented Approach
Notes	It is a sustainable urban design that efficiently utilizes natural resources to generate energy and enable water recycling.	The use of materials in natural cycles has inspired ETFE and ecosystem design in biomimicry.	The growth characteristics of coral reefs have inspired the expandable design of buildings to meet changing needs.	A sustainable design has been developed inspired by green roofs and ecosystem arrangements.	A sustainable urban design has been developed inspired by solar energy and natural ventilation principles.
Sustainability Contribution	✓ Solar and Wind Control ✓ Water Manag. ✓ Waste Manag. ✓ Energy Manag.	✓ Solar and Wind Control ✓ Water Management	✓ Design (Flexible Design)	✓ Local Vegetation ✓ Natural Ventilation ✓ Natural Lighting	✓ Energy Management ✓ Waste Management ✓ Transportation System