EXPLORING BIOMIMICRY IN PRODUCING SUSTAINABLE ARCHITECTURE: EVALUATING THE IMPACT ON BUILDING AND INTERIOR DESIGNS.

By
Batchman Ekure ISAAC Ph.D.
Department of Industrial Technology Education
University of Uyo,
Akwa Ibom State.

AND

Arc Peter Sunday USANGA
Department of Architecture
University of Uyo

Abstract

The application of biomimicry in sustainable architecture is examined in this study, with an emphasis on how it affects exterior and interior architecture. Biomimicry provides creative ways to build healthy and ecologically sustainable structures by taking cues from the patterns and processes found in nature. The study assesses how biomimetic concepts might improve external and interior architecture designs in terms of energy efficiency, material sustainability, and environmental harmony. The study looks at real-world applications and their advantages through case studies and biomimetic strategy analysis. Research show that biomimicry can result in major improvements in occupant well-being, structural robustness, and resource efficiency. The study ends with suggestions for using biomimicry into architectural design to promote sustainability and creativity, ultimately helping to create greener and more adaptable urban environments.

Keywords: Biomimicry, sustainable architecture, building designs, interior designs and levels of biomimicry.

Introduction

An inventive method of design and problem-solving that draws inspiration from nature is called biomimicry. This relatively young area uses billions of years of evolutionary history to generate creative, sustainable, and successful solutions. Environmental issues including the depletion of natural resources, the need for global alerts, and the rise in energy usage have pushed designers and architects towards sustainable design. The depletion of natural resources, the escalation of environmental issues, and the rise in energy use push architects and designers towards the creation of sustainable and eco-friendly structures. The main purpose of sustainable building is to reduce the negative impact of people on the natural environment (Ergun & Aykal, 2022). As a result of this Brownell & Swackhamer (2015) mentioned that one of the most important design practices designers as well as architects and scientists who observe nature should prefer is biomimicry. Designers are able to produce lightweight, resilient, and sustainable buildings by utilizing biomimetic materials. By imitating nature's tried-and-true solutions, biomimicry in architecture promotes sustainability by producing designs with reduced resource usage, waste

reduction, and environmental impact. Biomimicry also helps numerous sectors cut resource usage by imitating nature's efficient designs. Nonetheless, the core idea behind biomimicry is to emulate nature and make use of the biological concepts that have emerged as a result of evolutionary processes.

The fundamental idea behind biomimicry in architecture is to imitate the long-term, sustainable solutions that nature has evolved over billions of years. Engin, (2020) stated that nature has taken on an inspiring role in design fields from the past to the present. Through studying how living things handle intricate issues like waste management, energy efficiency, and climate adaptability, architects may create structures that blend in with their environment. As a result, buildings become more durable, generate less trash, and use less energy. Using biomimicry in interior design has many advantages as well, as it harmonizes human environments with natural laws. In addition to improving an interior's visual appeal, natural forms and materials also improve the health of its occupants. Interior designers may establish a stronger bond between individuals and their surroundings and encourage a sense of balance and harmony by designing spaces that reflect nature. Beyond its positive effects on the environment and human health, biomimicry also has an impact on interior and architectural design. In the world of architecture, it also stimulates creativity and innovation as it is a challenge for designers and architects to look beyond the box and experiment with novel building materials and methods influenced by the natural world. As a result, innovative technologies have been created, such as concrete that can cure itself and imitates the regeneration qualities of human tissues. These developments not only stretch the bounds of design but also open the door for stronger and more flexible constructions. Architects and designers may create attractive and practical structures and interiors that are also sustainable and regenerative by taking inspiration from and mimicking nature. With this strategy, there is hope for a time when urban growth and the environment may coexist peacefully, protecting the health of the earth and its inhabitants.

Concept of biomimicry

Otto Schmitt first used the term "biomimicry" in 1982. Janine Benyus rediscovered it in 1997 and defined it as deliberate problem-solving design that draws inspiration from nature. The Greek words "bios," which means "life," and "mimesis," which means "to imitate," are the source of the phrase "biomimicry." Sometimes, the term "biomimicry" is used incorrectly to describe the process of designing structures that mimic living things, such as structures shaped like shells, but actually use a distinct approach known as "morphology." As an area of study, biomimicry is defined as a solution for design challenges inspired by natural models, systems, and elements. Nevertheless, architects employ biomimicry as a concept to solve building problems and optimise energy efficiency. As an interdisciplinary approach, it can potentially yield sustainable solutions through the cooperation of engineers, architects, chemists, biologists, and physicists. According to Dash (2018) Biomimicry as a new science which studies nature as a model and an inspiration from which one can imitate its design and process to solve human problems. Furthermore, biomimicry is frequently described as an evolutionary process that draws inspiration from nature to create sustainable systems and processes that aim to alter the environment.

Fukey & Pradeep (2019) also defined biomimicry as a concept of adopting nature’s principles and applying it in engineering or science to help create a more sustainable built environment for future generations. Moreover, the biomimicry innovation draws inspiration from nature because it piques interest both throughout the design phase and after the project is

completed. To create a long-lasting future, it, in its broadest definition, imitates or draws creative inspiration from the mechanisms, effects, strategies, concepts, and systems found in nature. It is also a relatively recent multidisciplinary discipline that focuses on using lessons from nature to model its shapes, functions, and ecosystems in order to address problems for humans. Additionally, the study of biomimicry discusses how designers have utilized nature's patterns and emulation to help solve challenges for humans. Designers and architects have drawn a great deal of inspiration from nature for millennia.

As mentioned by Adebisi, Onuwe, & Sani (2015) biomimicry is a design sustainable tool. While it is an emerging field of study in the disciplines of engineering and architecture, biomimicry is also an interdisciplinary field in which biology and engineering interact and discuss at different levels of abstraction and within multiple iteration cycles. It is also far from being a novel concept, as it also focuses on the need to know the awareness level and the extent of adoption of this concept in architectural designs in Nigeria. A number of frameworks and instruments have been created to assist engineers in determining the best biological designs.

Fig 1: Biomimicry Design Environment

Fig 2: Biomimicry Design Environment

Concept of sustainable architecture

Sustainable architecture is an applied concept in the field of architecture that aims to promote the "concept of sustainability," which is the notion of protecting natural resources to last longer. Natural resources and the human ecological environment, including the planet's climate system, agricultural systems, forestry industry, and of course architecture, are vital to human survival. The idea of "sustainable architecture" aims to lessen the damaging effects that buildings have on the environment. Syam, Wisdianti, Saja, & Bahri (2023) explained that, the term sustainable is also known as green architecture. But sustainable development is a pressing issue in today's world which incorporates sustainable architecture. In addition, sustainable development satisfies human wants and desires without jeopardizing resources and environmental circumstances for future generations. As mentioned by Sirija (2013) sustainable architecture as an attempt to merge ecology and economy into one system. It also discusses how architects use environmentally friendly design principles in their work. The goal of sustainable design is to reduce the adverse effects of buildings on the environment through the optimization of material, energy, and development space utilization, as well as through efficiency and moderation. Furthermore, environmental concerns and the encouragement of human-nature ties are the roots of sustainable architecture. The design of sustainable buildings, or sustainable architecture, also helps to lessen the overall environmental effects of the building's lifecycle, construction process,

and the manufacture of its component parts. The efficiency of the heating and cooling systems is also emphasized in this design approach.

Kumawat (2020) also postulated that, the sustainable architecture is an architecture in which many different concerns such as design, materials, use of energy, cost, and the environment, are weave together in the interest of creating a functional structure which meets the needs of the present without compromising the ability of future generations to meet their resources. This architecture aims to reduce the adverse effects of buildings on the environment by increasing efficiency and practicing moderation in the use of resources, energy, development space, and the ecosystem as a whole. It also employs a deliberate strategy for ecological and energy conservation in the built environment design.

Wahed & Gabry (2021) asserted that sustainable architecture is a contemporary trend in architectural design, to balance the surrounding environment by better employing skills. One building method that lessens negative effects on the environment and human health is sustainable architecture, sometimes referred to as green design. By selecting an environmentally appropriate building, an architect or designer also seeks to conserve the land, water, and air. Using the architect's skills more effectively is regarded as a modern approach to architectural design that aims to achieve harmony with the surrounding environment. Architects can learn the finest practices for dealing with nature by introducing designs that consider the long-term effects on the environment when they are familiar with green architecture.

Concept of building designs

The term architectural design, or "building design," refers to the broad range of architectural, engineering, and technical applications to the design of buildings. Essentially, it is the process of taking a client's specifications for a new building or modifications to an existing building and turning them into a design that is agreed upon and that a contractor can then build. According to Yan, Yang, Peng & Ren (2020), building designs are generated to meet some specified design objectives, such as functional requirements, cost restriction, material type, performance criteria, and other requirements. Technical drawings and models that depict the designs, façade treatments, services, functional presentation, and construction process elements are the deliverables for a complete building design solution. To create a comprehensive design that satisfies the necessary needs and goals, building designs, on the other hand, integrate a number of components, including cost-effectiveness, sustainability, safety, and aesthetics, a building designer, usually a licensed architect or structural engineer, is needed for every building project.

As mentioned by Clements-Croome (2019), the life process of a building involves five stages in its metamorphosis which includes the design, construction, commissioning, facilities management and appraisal in use. The process of planning, designing, and constructing a building's layout, look, and functionality is included in these designs. To create a unified and harmonious design, it also includes incorporating structural, mechanical, electrical, architectural, and environmental factors. Moreover, building design includes the external and internal aspects of a structure. It includes figuring out the building's dimensions, shape, and layout; choosing the materials and finishes; organizing the locations of windows, doors, and other openings; and taking accessibility, lighting, and ventilation into account.

Zhang (2019) stated that Green building design concept can embody people's (individuals or occupants) healthy and green life concept in building construction, which is conducive to the

sustainable development of the construction industry and can create a harmonious environment between nature and human beings. Zhang further explained that the Green building design can also be conducive to resource regeneration and environmental protection. It is also claimed that building design is the science of organizing and carrying out a plan to physically incorporate all the requirements that an occupiable building must have. Additionally, because building design entails taking a client's ideas and requirements and processing them imaginatively into a design and delivering the output in a way that it can be physically constructed, it also considers factors like building codes, zoning regulations, environmental impact, and energy efficiency.

Fig 3: Biomimicry building designs

Fig 4: Biomimicry building designs

Concept of interior designs

The professional and all-encompassing process of designing an interior space that attends to, safeguards against, and fulfils human need(s) is known as interior design. It can also be referred to the process of organizing, managing, and carrying out the interior architectural building plans and furnishings. Udemy (2019) defined the term "Interior design" as the art and science of enhancing the interior of a building to achieve a healthier and more aesthetically pleasing environment for the people using the space (occupants). The art, science, and business planning of an innovative, practical, sustainable, and useful interior solution that harmonizes with a space's architecture are also included in interior design. According to Savage & Friedmann (2024), interior design is a specialized branch of architecture or environmental design that deals the planning and design of man-made spaces. Beautiful art forms like interior designs inspire interior designers to express their creativity and let the homeowner's personality come through.

Nonetheless, the field of interior design also include the planning and arranging of the ornamental aspects found within a home or other enclosed area, such as color palettes, fixtures, furniture, and occasionally architectural elements. The capacity of interior designers to produce visually appealing designs that also satisfy the needs and desires of the occupants is the main focus of interior design. It is also a means of getting people to engage with, observe, and interpret the artistic creations that are out of place in their surroundings. Willcox (2023) explained that through interior designs, professionals try to make their environment better, safe and understandable. Since interior design is a way of life, it also entails blending psychology, commerce, and the arts. The act of developing, altering, and arranging interior space elements to meet tenant needs and specifications while also guaranteeing the area's safety, functionality, and aesthetic appeal is sometimes referred to as interior design. While interior design acts as a reflection of a person's

taste, style, and demands, art pieces serve as a vehicle for the expression of human feelings. It is also a useful and applied art that helps to solve issues for people.

Fig 5: Biomimicry interior design

Fig 6: Biomimicry interior design

Levels of biomimicry

The technique of studying and imitating the structures and functions of nature in order to find long-term answers to issues facing humans is known as biomimicry. Nonetheless, biomimicry urges designers to mimic and create structures that resemble nature on three basic levels. Every level concentrates on distinct facets of nature and employs its principles in diverse manners to create solutions that are sustainable. The following are included in the three biomimicry levels:

Organism or Form biomimicry level: Imitating natural forms, structures, materials, and organisms is part of the form mimicry level. The level is concerned with the physical characteristics of living things and ecological systems. The form of natural things can be studied by architects and structural designers to produce more sustainable, long-lasting, and effective products.

Fig 7: Example of organism or form biomimicry structure

Behavioral or Process Biomimicry level: The behavioral biomimicry level involves the mimicry of how the organism or nature behaves or relates to its larger context (Othamani, Yunos & Ramlee, 2022). This level, however, is concerned with the strategies and mechanisms that organisms employ to carry out their tasks. It also entails applying an understanding of natural biochemical and physical processes to technology and industrial activities.

Fig 8: Example of process or behavioral biomimicry structure

Ecosystem Biomimicry level: The links and interactions found in natural ecosystems are examined at this mimicry level. As mentioned by Zari (2007) cited in Ismail & Rahman (2018), the ecosystem level however involved what could be studied to look for specific aspects to mimic. In order to construct systems that are robust, sustainable, and regenerative, all characteristics that characterize natural ecosystems this degree of mimicry expresses the relationships and interactions found within those ecosystems.

Additionally, designers and engineers can create creative solutions that are effective, sustainable, and in harmony with nature by comprehending and putting the ideas of biomimicry to use at each level.

Fig 9: Example of ecosystem biomimicry building

The need of biomimicry architecture in building

Studying the forms, functions, and processes found in nature and incorporating them into architectural design is known as biomimicry architecture. This method attempts to mimic the natural world's design in order to produce more robust, efficient, and sustainable buildings. That being said, architects and designers can create creative and long-lasting solutions that tackle societal and environmental issues by taking inspiration from and mimicking the principles found in nature. The following are some reasons why a building needs biomimicry architecture:

Environmental Sustainability: One technique to design environmentally sustainable structures is through the application of biomimicry. According to Ergun & Aykal (2022), sustainable building is one of the most important reason for using biomimicry architecture in buildings. Buildings'

environmental impact can be lessened by using biomimicry, which mimics nature's economical use of resources and energy. Using natural principles, for example, can result in the production of materials that are lightweight and strong at the same time, minimizing waste and the need for unnecessary raw materials.

Resource Conservation: In the closed-loop system of nature, trash from one process is recycled into another. Additionally, biomimicry promotes the design of structures and systems that emulate this zero-waste methodology. On the other hand, biomimetic designs are based on shape rather than material, since the shape is cheap and material is expensive (Verma, 2023). Architects can reduce their environmental effect by designing buildings with materials and techniques that can be recycled, reused, or decomposed. This reduces the amount of non-renewable resources used in construction and demolition waste.

Resilience and Adaptability: Natural systems are by nature robust and flexible to changing environments. Buildings' ability to withstand environmental pressures like severe weather, earthquakes, and other natural calamities can be improved with the use of biomimetic design. For example, structures that draw inspiration from the shock-absorbing properties of spider silk or the flexibility of bamboo are more resilient to seismic activity. Furthermore, structures that are made to adjust to shifting environmental conditions might offer long-term usefulness and sustainability.

Health and Wellbeing: Human health and well-being are positively impacted by natural surroundings. By incorporating features like natural light, ventilation, and organic materials, biomimetic design can create environments that encourage comfort, lower stress levels, and increase productivity. For example, fractal patterns in nature can be mirrored in interior designs to create serene and beautiful spaces. Incorporating biophilic design elements such as indoor plants and green walls, can also enhance air quality and promote a sense of connectedness to nature.

Innovation and Inspiration: After 3.8 billion years of development, nature has developed incredibly creative and effective solutions for a variety of issues. Architects and designers can create innovative building technologies and design approaches by researching and replicating these solutions. Mattar & Alzaim (2023) postulated that in the eyes of designers and construction builders, nature’s different levels of complexity and forms have served as a basis of inspiration in the design and construction of buildings. However, solving several problems in architecture is only through innovative solutions, the models inspired by nature can cause creativity and innovations in the architect’s mind (Haruna, 2017). This supports a philosophy of constant learning and adaptability in addition to pushing the limits of architectural design.

Economic Benefits: Because biomimetic design requires specialized materials and research, the initial expenses may be greater, but there may be significant long-term economic benefits. Resilient structures require less maintenance and repair, while energy-efficient buildings save operating costs. Buildings that support health and happiness can also lower healthcare expenses while increasing productivity. The creative advantage that biomimicry offers can also boost a property's worth and competitiveness in the market.

Impact of biomimicry on building and interior designs

Biomimicry, the process of applying human problem-solving techniques to natural systems, has had a profound influence on architecture and interior design. Architects and designers are able to create surroundings that are more efficient, visually appealing, and sustainable by taking

inspiration from natural shapes, processes, and ecosystems. The following are some significant effects of biomimicry on architecture and interior design:

Energy Efficiency: Biomimicry has led to the development of energy-efficient building designs by emulating natural processes and systems (Pearce, 2018). Termite mound-inspired ventilation systems allow buildings to maintain consistent interior temperatures without a significant reliance on mechanical heating or cooling systems. This design dramatically lowers energy use by eliminating the need for traditional air conditioning.

Material Innovation: Architecture's use of material science has been transformed by biomimicry. Researchers and designers are developing materials that mimic the properties of natural substances, leading to innovative and sustainable construction solutions (De Jong, 2017). Biomimetic Design based its designs more on shape than material because the shape is cheap and the material is pricey. Biomimicry has the potential to lower a company's material costs while increasing the effectiveness of product patterns and forms.

Water Management: Additionally, biomimicry has improved building water management. Systems inspired by natural water collection and filtration processes have been integrated into architectural designs to optimize water use (Koh & Lee, 2018). Buildings are adopting green walls and roofs to filter rainfall, lessen runoff, and enhance water quality, emulating the filtration qualities of wetlands.

Indoor Environmental Quality: By using biomimicry into interior design, indoor environmental quality is improved and occupant comfort and well-being are increased. It has been demonstrated that the idea of biophilic design, which integrates natural elements into interior environments, lowers stress, enhances cognitive function, and raises overall enjoyment. Examples include the use of natural light, indoor plants, and materials with natural textures and patterns (Kellert, 2019).

Resilience and Adaptability: The capacity of nature to adjust and react to shifting circumstances provides important design lessons for sturdy and flexible structures. Professionals can design structures that are resilient to a range of environmental stressors, including harsh weather, earthquakes, and rising sea levels, by examining the tactics used by nature.

Roles of biomimicry in producing sustainable architectural buildings

Using lessons from nature, the notion of biomimicry can be applied to create sustainable solutions to human challenges. According to (Aykal & Ergun, 2022), the main purpose or aim of sustainable building is to reduce the negative impact of people to the natural environment. However, Nature provides a variety of different types of systems and models for humanity that can be imitated and exploited to design buildings and projects in harmony with Nature and its systems (Wahhab & Rizko, 2022). It also contributes significantly to the creation of sustainable architectural structures by utilising the tried-and-true patterns and techniques found in nature. Among the roles are the following:

Energy Efficiency: One cutting-edge approach to designing more energy-efficient designs is biomimicry. In biomimicry for sustainable building, energy efficiency refers to the practice of reducing energy use by mimicking natural systems. For instance, buildings can imitate animal insulation for better thermal performance, leaf structures for natural illumination, and termite mounds for passive cooling. These biomimetic designs minimize operational expenses, improve energy efficiency, and lessen their negative effects on the environment.

Water Management: By copying the effective mechanisms seen in nature, biomimicry in sustainable building improves water management. For example, structures can be designed to capture water using desert beetle designs or to imitate plant structures for natural filtering. These methods decrease waste, increase water conservation, and blend in well with the surroundings.

Material Innovation: Creating sustainable building materials by imitating the robust and efficient materials found in nature is known as material innovation in biomimicry. For example, architects may design materials based on the resilience of seashells or the strength of spider silk, which would result in more long-lasting, environmentally friendly building solutions.

Structural Design: In structural design, biomimicry is the process of modelling natural forms and systems to create robust, and effective structures. Buildings, for instance, can be designed to resemble the robust yet lightweight structures of bones or honeycombs, resulting in more environmentally friendly designs that use fewer materials and have higher longevity.

Climate Adaptation: In biomimicry, climate adaptation refers to the construction of structures that adapt to their surroundings by imitating naturally occurring climate-responsive techniques. For instance, buildings can control temperature with adaptable facades modelled after plant movements, increasing resilience and consuming less energy.

Biodiversity and Ecosystem Integration: In biomimicry, biodiversity and ecosystem integration refer to the design of structures that sustain and improve nearby ecosystems. Through the implementation of natural habitat-like elements, including wildlife-friendly features or green roofs, these designs foster biodiversity and create a harmonious relationship with the surrounding environment.

Aesthetic and Psychological Benefits: By using natural forms and patterns, biomimicry in architecture can produce aesthetically beautiful and peaceful spaces that have both psychological and aesthetic benefits. By encouraging a connection with nature, designs inspired by nature not only boost a building's aesthetic appeal but also the well-being and contentment of its occupants.

Importance of biomimicry in interior design

Interior designers should take note of biomimicry, since it promotes sustainability by copying nature's tried-and-true solutions, resulting in designs that consume less energy, produce less waste, and have a smaller environmental effect. However, biomimicry facilitates the connection between homeowners and nature in a variety of ways, including the introduction of living plants into indoor spaces. The following are the main reasons that biomimicry matters in interior design:

Enhanced Sustainability: As mentioned by Awadalla (2023), biomimicry is often described as a tool to increase the sustainability of human designed products, materials and the built environment. Biomimicry assists in the creation of more sustainable interior designs by mimicking natural processes. This entails cutting waste and maximizing energy utilization, as well as utilizing materials that replicate the robustness and effectiveness of natural materials.

Improved Health and Well-being: Natural lighting, comfort, and indoor air quality can all be improved with designs influenced by nature. Biomimetic ventilation systems, for example, increase airflow, and natural patterns and colours enhance psychological health and lower stress.

Aesthetic Appeal: By incorporating organic shapes, textures, and patterns into interior spaces, biomimicry produces aesthetically pleasing and peaceful settings. According to Verbugghe, Rubinacci & Khan (2023), biomimicry applied to architecture can satisfy numerous needs at once. Nonetheless, the use of biomimicry in interior design can enhance the ambiance and make the room more enjoyable.

Efficiency and Functionality: Innovative approaches to functionality and space usage can result from modelling the effective systems found in nature. Interior spaces can be made more comfortable and useful by implementing features like climate control systems or adaptable lighting that draw inspiration from natural processes.

Aids in connecting to Nature: The incorporation of natural components and biomimetic designs in interior environments promotes occupant contentment, tranquilly, and balance, which aids in strengthening the bond between the inhabitant and the natural world.

How biomimicry helps architectural designers

Using natural systems, models, and features as a source of inspiration to address human problems is known as biomimicry, and it gives a significant perspective on architectural design. Aside from being aesthetically beautiful, highly efficient, ecological, and resilient structures can be designed by architects by drawing inspiration from the shapes, functions, and ecosystems found in nature. According to Pawlyn (2019), biomimicry in architecture helps architectural designers to look to the natural world in achieving radical increases in resource efficiency. However, biomimicry is important to architectural designers since it aids in the creation of sustainable and energy-efficient building designs. The following are some ways that biomimicry might assist architects:

Innovative Design Solutions: Over billions of years of evolution, nature has mastered a variety of responses to environmental problems. This enormous body of knowledge can be tapped into by architectural designers to address challenging design issues. This invention greatly reduces energy usage by doing away with the requirement for traditional air conditioning.

Structural Strength and Efficiency: Since natural structures frequently strike an amazing balance between strength and efficiency, architects can imitate these features to produce structures that are structurally sound but require less resources. For example, the architecture of honeycombs provides insights on producing materials that are both strong and lightweight. Such biomimetic designs can result in novel, long-lasting, and sustainable building techniques and materials.

Economic and Long-term Benefits: Given the low cost of design, biomimicry aids architects in creating sustainable building designs. Buildings using biomimicry typically have lower operating costs because of their sustainability and efficiency. Due to the growing popularity of eco-friendly spaces among businesses and consumers, these buildings may also command greater market prices. Moreover, biomimetic designs typically have a higher degree of resilience, which lowers the cost of maintenance and environmental change adaption.

The essential elements of biomimicry

Using nature as a source of inspiration to address human problems is known as biomimicry, and it is particularly useful in sustainable design. Benyus (2023) mentioned the three essential elements of biomimicry which are; emulate, ethos and reconnect.

Emulate: A key component of biomimicry, a field that aims to address problems facing humans by replicating the tried-and-true routines and tactics of nature, is "emulation". This procedure entails examining and imitating the effective structures and operations present in the natural world. Scientists and engineers can develop innovative solutions that are sustainable, effective, and flexible by modelling these biological models. For example, the way burrs adhere to animal fur influenced the invention of Velcro, while contemporary wind turbine blades imitate whale flippers to increase efficiency. In biomimicry, the fundamental idea of emulation is to comprehend and incorporate the underlying principles that underlie the success of natural systems, rather than merely replicating their shapes.

Emulation in biomimicry necessitates an interdisciplinary approach and a thorough understanding of biological processes. In order to understand the intricate relationships and functions that have developed over millions of years, researchers must examine a variety of creatures and ecosystems. Following its translation into practical applications for people, this knowledge frequently results in advances in architecture, technology, and medicine. For instance, research on shark skin has produced surfaces with improved hydrodynamics and decreased bacterial growth. Engineers have created sophisticated water purification systems by mimicking the effective water filtration techniques of specific plants. These developments demonstrate how biomimicry can offer environmentally favorable and sustainable solutions. As environmental and resource concerns become more pressing for humanity, the importance of emulation in biomimicry is becoming more widely acknowledged. We can create technologies that are environmentally friendly and efficient by drawing inspiration from nature. Emulation promotes a change from traditional, frequently harmful to the environment methods to restorative and regenerative ones. It creates a more sustainable attitude to innovation and a greater respect for the complexities of the natural world. Emulation plays a critical role in pointing the way towards more resilient and sustainable future as biomimicry develops.

Ethos: Ethos, or the guiding principles or values that define a group or philosophy, is a key component in biomimicry. It is based on ethos to make sure that the discoveries and applications that come from biomimicry are in line with ethical and sustainable values. This method promotes a great regard for the natural world and solutions that are not only creative and effective but also environmentally friendly. Practitioners of biomimicry ensure that their works positively impact ecological balance and human well-being by incorporating ethos into their designs, which reflects a comprehensive understanding of sustainability. By incorporating ethos into biomimicry, one may uphold a dedication to developing resilient and regenerative designs that honor the limits and potential of the earth.

Reconnect: A key tenet of biomimicry is reconnect, which highlights the significance of re-establishing a healthy relationship between humans and the natural world. This idea promotes a change in viewpoint where nature is viewed as a mentor and role model rather than just a resource to be exploited. It does this by advocating for a thorough study and respect of the complexities and systems of nature. Humans can discover creative and sustainable solutions that complement natural processes, building resilience and lessening their influence on the environment, by getting back in

touch with nature. The development of efficient, sustainable, and ecosystem-symbiotic technologies and designs is contingent upon this reconnection, as it will ultimately foster a more sustainable and harmonious coexistence.

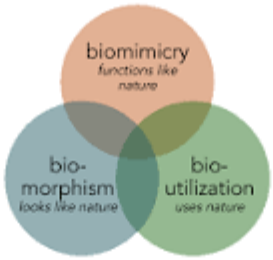

Fig 10: The three essential elements of biomimicry

Conclusion

Biomimicry has shown significant potential in various aspects of sustainable architecture. From energy-efficient buildings inspired by termite mounds and passive cooling systems to innovative materials mimicking the properties of natural substances, the applications are vast and impactful. The exploration of biomimicry in producing sustainable architecture offers a promising pathway toward more efficient, resilient, and environmentally friendly building and interior designs. By emulating nature's time-tested patterns and strategies, architects and designers can create structures that harmonize with their surroundings and utilize resources more prudently.

Recommendation

1. It is recommended that architectural schools and design programs should incorporate biomimicry into their curricula and the courses should cover the principles of biomimicry, case studies of successful implementations, and practical design projects that entails the students to apply biomimetic concepts.
2. It is advisable that architects should collaborate with biologists, ecologists, and engineers to better understand natural systems and how they can be translated into sustainable design solutions.
3. However, governments, private investors, and environmental organizations should allocate funds for research and development in biomimicry. As this investment can lead to the discovery of new materials, construction methods, and design strategies that are inspired by nature.
4. It is advisable to incorporate design elements that enhance energy efficiency, such as natural ventilation systems modeled after termite mounds or building facades that mimic the thermal regulation of certain plants.

REFERENCES

Adebisi, G.O., Onuwe, J.O., & Sani, A. M. (2015) Assessment of Biomimcry Design Concept Adoption in: Towards a Sustainable Built Environment in Nigeria. *Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*. 9 (4) 41

Awadalla, R. R. (2023), Biomimicry as an Innovation Behavior in Architecture and Interior Design. *Journal of Design Science and Applied Art.* 4(1): 81-92.

Benyus, J. M. (2023). *Biomimicry: Innovation Inspired by Nature. Updated Edition. HarperCollins.*

Brooker G. & Stone S. (2024). What is Interior Design? Available at: https://www.academia.edu/191827/What_is_Interior_Design

Brownell, B., & Swackhamer, M. (2015). Hyper- natural Architecture's New Relationship with Nature (M. Baber, Ed.). Princeton Architectural Press.

Clements-Croome D. (2019) The role of feedback in building design 1980–2018 and onwards. *Building Services Engineering Research and Technology.* 40(1):5-12. Doi: 10.1177/0143624418812982.

Dash S. P. (2018) Application of Biomimicry in Building Design. *International Journal of Civil Engineering and Technology, 9(2), 2018, pp. 644–660.* http://iaeme.com/Home/issue/IJCIET?Volume=9&Issue=2

De Jong, T. (2017). Biomimicry in Architecture. *Architecture and Design Journal*, 25(4), 223-230.

Engin, H. E., Ataman, M., Bal, H. B., & Bekar, İ. (2020). *A Studio Experience on Furniture Design in Interior Architecture Education*: Bank Design with Analogical Approach. VI. International Furniture Congress, 8–15

Ergun R. & Aykal D. F. (2022) The use of biomimicry in architecture for sustainable building design: a systematic review. *International Journal on Sustainable Tropical Design Research and Practice.* 15(2): 24-37.

Fukey L. N. & Pradeep S. (2019) Biomimicry: an approach to sustainable architecture and design. *International Journal of Life Sciences Research*. 7 (1) 319.

Haruna A. (2017). Adaptation of Biomimicry Architecture Principle for Energy Efficiency in Civic Centre Lokoja, Kogi State, Nigeria. Available at: http://repository.futminna.edu.ng:8080/jspui/bitstream/123456789/12661/1/ADINOYI%2C%20Haruna%20Main%20thesis.pdf

Ismail, A. N. & Rahman, A. A. (2018), Review on Biomimicry levels. *American Journal of Humanities and Social Science Research (AJHSSR).* 2(8):55-58.

Kellert, S. R., Heerwagen, J. H., & Mador, M. (2019). *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*. John Wiley & Sons.

Koh, T. Y., & Lee, J. (2018). Biomimetic Design and Architecture: Nature as a Model. *International Journal of Architectural Research*, 12(3), 45-60.

Kumawat V. S. (2020) Review Paper on Sustainable Architecture. *Journal of Emerging Technologies and Innovative Research (JETIR) www.jetir.org*. 7 (7) 1125

Mattar Y. & Alzaim M. A. (2023). Applications of Biomimicry in Architecture, Construction and Civil Engineering. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10204470/

Mortice Z. (2021). Nature does it better: Biomimicry in architecture and engineering. Available at: https://www.autodesk.com/design-make/articles/biomimicry-in-architecture

Othmani, N.I., Yunos, M. Y. M. & Ramlee, N. H. A. (2022) Biomimicry levels as design inspiration in design. *International Journal of Academic Research in Business and Social Sciences.* 12(8):1094-1107.

Pawlyn, M. (2019). *Biomimicry in architecture. Riba Publishing.*

Pearce, A. (2018). Sustainable Buildings and Infrastructure: Paths to the Future. Routledge.

Savage G. & Friedmann A. A. (2024) *interior design. Encyclopedia Britannica. https://www.britannica.com/art/interior-design*

Sirija M. (2013) Necessity of sustainability in architectural practices for achieving sustainable development. Available Online: http://recent-science.com/ 5 (5) 79

Syam F. H., Wisdianti D., Sajar S., & Bahri S. (2023) Study of Sustainable Architecture Concepts. *International Journal of Research and Review*. 10 (4) 419

Udemy (2019). Introduction to Interior Designing. Available at: https://www.udemy.com/course/introduction-to-interior-designing/?

Verbrugghe N, Rubinacci E, Khan AZ. (2023) Biomimicry in Architecture: A Review of Definitions, Case Studies, and Design Methods. *Biomimetics.* 8(1):107. https://doi.org/10.3390/biomimetics8010107

Verma S. (2023). Biomimetic Design in Architecture: Origin, Pros, Cons, and its Application. Available at: https://www.novatr.com/blog/biomimetic-design-in-architecture#:~:text=It%20can%20reduce%20material%20costs,the%20product%20patterns%20and%20forms.

Wahed A. & Gabry A. E. (2021) A Vision for Green Architecture and Sustainability. *International Journal of Advances Engineering and Civil Research*. 1 (2) 29-30

Wahhab, A. K. & Rizko, J. N. (2022) The Role of Biomimicry in Producing Sustainable Architecture. *ISVSe-journal.* 9(5): 368-386.

Willcox (2023). Introduction to Interior Design. Available at: https://www.g-w.com/assets/files/pdf/sampchap/9781619602427_ch01.pdf

Yan, H., Yang, N., Peng, Y. & Ren, Y. (2020) Data mining in the construction industry: Present status, opportunities, and future trends. *Automation in Construction, Volume 119, 103331.* Doi: https://doi.org/10.1016/j.autcon.2020.103331.

Zhang W. (2019) Analysis and Research on the Application of Green Building Design Concept in Architectural Design. *Frontiers in Art Research.* 1(5): 48-53. ISSN 2618-1568, DOI: 10.25236/FAR.2019.010509.