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Exploring the Place of Nature Strategies in Architecture Design Process Towards Nature and Built Environment Symbiosis

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ABSTRACT

There are sustainability strategies in nature, which are the key to the survival and stability of components and ecosystems. Not only nature is a source of inspiration, and innovative ideas in solving human problems also is a powerful mentor for designing the built environment in symbiosis with the substrate ecology. Due to nature strategies' complexities and their interdisciplinary character, the architectural design process needs to be known by nature-inspired framing. With the wide scale of biological information and the lack of recognition of applying nature strategies, a model is needed to use biological strategies in the architectural design process. This research aimed to explore the nature-strategies effective components in the architectural design process, to create a connection between the biological and architectural domains. Using the nature strategies to transfer, and apply them in the architectural domain, as well as how the nature strategies affect and transfer in the field of architecture have been explored by studying the nature-inspired design strategies and the projects and documentation of the experts in this field through theoretical Analysis, focus groups, and also logical argumentation and case study. The analysis of qualitative data was done with Fisher's exact test, and SPSS software was used. The main question of the research has been raised as follows: What are the effective components of nature-inspired strategies and their place in the architectural design process? The research findings show that discovering and explaining the effective nature-inspired design components in the design process creates new paths to reaching innovative designs.

Keywords: *Nature Strategies, Architecture, Design process, Nature and Built Environment Symbiosis.*

1. Introduction

an organism that that organism needs to survive. Throughout history, nature is the oldest, smartest, and most complex teacher of mankind. Nature has achieved sustainability and survival based on several key principles. Considering the minimum needs of living organisms, nature has guaranteed its survival, adaptation, environmental stability, independence, flexibility, accuracy, diversity, and regeneration [1]. By following these principles, natural organisms continue to live without

Understanding the world around us is especially important as a source of inspiration for designers and architects; Why and how can the knowledge of nature be used in the design process? and also what is the achievement of using this knowledge? The reason for the instability of human life today lies in nature and culture, it is in nature that humans and also living things unite together [2]. Nature-inspired design strategies are design strategies based on learning and modeling nature as sustainable patterns [3].

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Designers and architects can benefit from the development of nature's self-made approach and use the resulting knowledge to achieve sustainable societies and systems. According to the findings of the Biomimicry Institute, the more similar the built environment is to the natural world, the more likely it is to survive, and this is a special concept of sustainability. Nature has created complex mechanisms and methods to continue survival; By knowing and learning from nature in solving design and architecture problems, new technologies in different fields to solve them can be achieved. It should be noted that life and nature are not separate from each other and man is also a part of it. As a result, the barriers and components that separate man and nature should be identified, and by examining and understanding their function in nature, Let's use them as a tool to solve human problems [4]. The fundamental problem for designers and architects is that, despite the systematic methods, there are few tools for integrating and solving problems at the same time; For this reason, they must adopt a set of different approaches, various interpretations, principles, and frameworks of these approaches to achieve a complete solution [5].

The purpose of reviewing and developing nature design strategies for designers and architects is to make a selected abstract of the achievements of sustainability theories available to experts and designers in this field. For this purpose, different periods of sustainability, the main perspectives of sustainability, statements, principles, frameworks, and tools have been reviewed and classified that have been proposed in the last fifty years and are suitable for design. Some notable points of this study are:

- Many principles and frameworks are concerned with environmental sustainability.
- Some of them are based on systematic methods focused on environmental and social fields.
- Some tools and frameworks, although they seem very efficient, have not been considered and used.
- There are many sources for choosing materials, production techniques, energy, waste, and also the social impacts of design; However, few of them address the effects of design on culture and the role that culture plays in sustainability.

In summary, although useful information is currently available, it is unfortunately incomplete and very scattered. Also, there is no information about the effects of design on the preferences and habits of the audience based on these approaches. To achieve sustainable design, designers and architects need a shared understanding of the interrelationship of the four components of sustainability, which are: environmental protection, social equity, economic health, and cultural vitality [6]. This research has been formed to answer the "What are the effective components of nature-inspired design strategies and where is their place in the process of creating architecture?". The field of research literature includes two main parts of nature-inspired design strategies and the architecture design process, each part begins with a literature review of that part.

1. Material and Methods

1.1. Research Methods

By conducting theoretical and documentary studies, reviewing the existing literature on the effects of using nature-inspired design strategies, and extracting their effective components in achieving nature and built environment symbiosis, the subject was extensively investigated with the approach of multiple case studies (Fig 1). Based on the studies of available sources, a set of indicators and criteria in the form of influential keywords have been taken from the nature design strategies, which in this research are in the form of three selected strategies, i.e., Biomimicry, Cradle to Cradle, and Hanover Principles[1], as well as an

[1] In order to determine which strategies should be chosen in the research project, the different periods of sustainability, the main perspectives of sustainability, statements, principles, frameworks, and tools that have been proposed in the last fifty years and suitable for design were reviewed and classified, as well as a comprehensive list. We analyzed sustainable design strategies provided by AIGA. This list consisted of thirty sustainable approaches which are used in different disciplines that are a subset of design over the last fifty years. Our main goal was to select those that can be introduced as "Nature inspired design strategies", in this regard, the following criteria were applied as three strategies selection filters:

- Filter one: attention to nature; The question raised in this filter is: Does the strategy explicitly refer to nature?
- Filter two: modeling nature in the design process; The question raised in filter two is: Which of the selected strategies in filter one has used nature in the design process? This means that after identifying the traces of the use of nature in filter one, in which of the strategies has nature been used as a source of design inspiration, design principles, tools, or design goals or methods for design?

approach that is older and more familiar among architecture activists which is Eco-design. That is, the Eco-design (as a control approach) was extracted and put to the test. In this part of the research, the extent, and scope of the influence of nature-inspired design strategies in the architectural process were focused on and investigated so that by testing the assumptions of this part of the research, effective components of nature's strategies have been explored in the architectural design process. To test this model, a Focus group (Participant Observation) was conducted in the form of a researcher-made test in the statistical population of "Man, Nature, Architecture" students of Islamic Azad University, Mashhad Branch, and Tehran Science and Research Branch (Table 1). The statistical population included 132 students in three consecutive semesters. In order to ensure the validity and reliability of researcher-made tests, a pre-test has been conducted. In explaining the reason for choosing the course "Human, Nature, Architecture" in conducting this research, it can be acknowledged that: the course "Human, Nature, Architecture" is presented in the third semester and at this stage, the architectural character and general principles of the student's design have not yet been formed and are also influenced by the methods The lecturers are not assigned to design courses, and at the same time, they have learned the basic principles and basics of design by passing the course on the basics of "Architectural Design 1", which is a prerequisite for the course "Human, Nature, Architecture". The analysis of qualitative data was done with Fisher's exact test, and SPSS software was used.

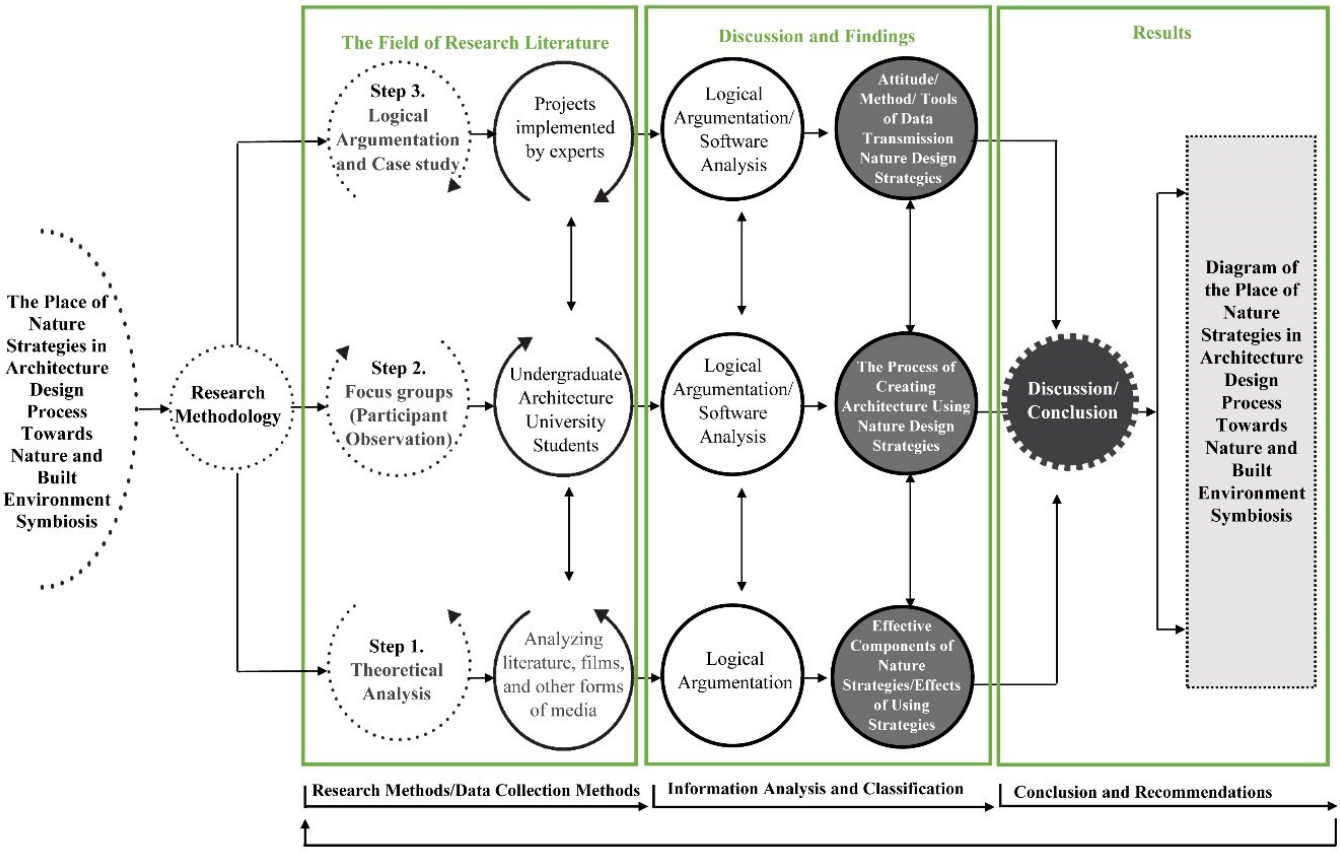


Fig 1: Steps and level of research methodology diagram

- Filter three: using nature in the creation of architecture; The question raised in the third filter is: In which of the strategies has nature been used as a source of inspiration in the creation of form/process or system in the creation of architecture?

After studies and based on defined filters, Biomimicry, Hanover principles, and Cradle to Cradle are approaches that have used nature as a source of inspiration in the creation of architecture. In summary, Biomimicry, Hanover principles, and Cradle to Cradle were selected after analysis based on filters defined as nature-inspired design strategies for the current research study.

Table 1: Research methodology

Gathering information on the architecture design process inspired by nature				
Approach	**Focus groups (Participant Observation)**			**Case Study**
	Pretest	***Test***		
	Second semester Islamic Azad University of Mashhad ***9 groups***	First semester Islamic Azad University of Mashhad ***24 groups***	Second semester Islamic Azad University Science and Research Branch ***24 groups***	Logical Argumentation and Case study ***10 Projects***
The Hannover Principles (HP)	3 groups (n=4)	6 groups (n=2)	6 groups (n=2)	2 Projects
Biomimicry (Bio)	3 groups(n=4)	6 groups (n=2)	6 groups (n=2)	3 Projects
Eco-design (Eco)	3 groups (n=4)	6 groups (n=2)	6 groups (n=2)	3 Projects
Cradle to Cradle (C2C)	-	6 groups (n=2)	6 groups (n=2)	2 Projects

In the following, Logical Argumentation and Case study were conducted to test the findings of the documentary studies and the Focus groups. In the sense that the projects of the experts of each approach were selected and by studying the available documents as well as the visual reports that were available from the projects, the usage of the extracted components and the method of using them were examined based on the type of design approach (Section 3). After that, the effective components of nature's strategies in the architectural design process were presented in a model in order to achieve the coexistence of the built environment with nature (Fig 8), also the effectiveness of using nature's strategies in the design process was compared with each other in both practical and theoretical areas (Fig 9). Finally, a model was set up to explain the place of using nature-inspired design strategies in the Architectural design process (Fig 10).

1.2. Theory

1.2.1. Nature-Inspired Design Strategies

Natural organisms can be recognized as a rich source of ideas for more efficient structures than existing examples. The rigors and all-encompassing pressures of trying to survive, finding food, regulating temperature, mating, reproducing, and avoiding predation, have caused genetic mutations, adaptive structures, and new combinations over the centuries. Certainly, this process continues in nature and what we are witnessing today is the best and most evolved structures throughout the life history of the earth. The main thing that can be learned from nature in the field of architecture is fewer materials and more design. By exploring the patterns of nature, one can find many examples to study and model in order to achieve the goal of using minimum materials in line with maximum efficiency. A system, in its simplest form, controls and uses its elements and components for a specific function or purpose. Some biological models are more suitable than others for the desired function or system [7]. Ecosystem principles can be used on different scales. The use of ecosystem models is a more suitable method for cities or parts of cities than the metabolism model of an organism due to the diversity, extent, and variety of members with a high degree of dependence and dynamic balance. Ecosystems have the advantage of minimizing the amount of energy and resources received, as well as the amount of their loss. Of course, there are exceptions to the above-mentioned characteristics in human systems compared to biological systems, but the general characteristics apply in many cases, and often its advantages become more pronounced as human systems develop. In biological systems, millions of members are active in the system without interruption and full of countless opportunities, they work like successful entrepreneurs in nature, and species evolve to develop a wide ecological range; However, in man-made systems such as large multinational companies, decision-making power is in the hands of limited people, and also all members are not always active and creative entrepreneurship is limited. Cities develop vast resources that become waste in a linear system or if not properly designed. Ecosystems offer a different paradigm in which all nutrients contribute and can be infinitely recycled. Ecosystem models are also highly resilient. One of the most important differences between man-made systems and ecosystems is that: man-made systems

are non-renewable, while ecosystems are renewable and regenerative. Janine Benyus expresses this issue as follows: "Life creates favorable conditions for life" [8].

The more complete the ecosystem, the more they enhance their environment and create a wider diversity. As a result, nature can be used as a guide and reference to achieve sustainable solutions. Therefore, we defined the term "Nature-Inspired Design Strategies" as a general term or definition as follows: strategies derived from nature are strategies that are based on "learning from nature" and consider nature as a stable paradigm.

1.2.2. Architectural Design Process

Architectural design can be considered a process that is compiled in various ways and with several generalization capabilities. In architecture, the design process of an architect includes a large number of decision-making and development stages, which ultimately create an imaginary concept from reality and is realized in the future [9]. The scope of design is so wide that it may not be possible to imagine a single definition for it. Architecture in the broad field of design is an analytical process that requires problem discovery, analysis, synthesis, evaluation, and selection. In fact, design can be seen as an effort to invent solutions before implementing them [10]. Every creative idea has a lineage. This means that even innovative and creative ideas that are proven to be new have originality in past ideas [11]. In 1970, J.C. Jones divides the evolution of design methods into four eras the development of art and craft, design with the help of drawing and systematic design, and design in the present era. In the era of the development of art and craft, artisans created their work with the help of their limited tools with a direct connection between mind and hand. In the period of drawing-based design (Renaissance to 1950), the designer's method was not obvious to anyone but him, and sometimes even the designer did not clearly know how the problem was solved. Systematic design began in the 20th century and was according to the military needs of World War II. At this stage, design has been a tool to solve a micro-problem and a part of a larger system. The present age is the age of rapid technological changes or technological social innovations. One of the modern methods of assessing the problem and discovering the plan in the contemporary period is the principle of changing the strategy and allowing the penetration of uncontrollable thinking into planned thinking and vice versa [12]. Horst Rittel divides the models presented for the design process into two generations. While the first generation (the 1960s) is defined based on scientific, rational, and systematic methods; The second generation (from the early 1970s) is to increase the participatory design process and introduces the environmental designer as a partner of the problem owners (employers, customers, users, and social groups) [13]. After referring to Rittel's theory about the two generations of rational and argumentative models, John Lang points to the emergence of a new generation of design under the title of hypothesis building and testing, which was formed under the influence of Popper's theories and relies on the mental structure of the designer himself [14]. Ashraf Salame introduces three models for the design process. The first is the intuitive model (black box approach) and the second is the rationalistic model or problem-solving (glass box approach). For the rationalist model, he lists two systematic design approaches and pattern language. The third model, the collaborative model, refers to the approach of action research or collaborative design [15]. In the first generation (the early 1960s), the design was emphasized as a problem-solving activity, Van de Voort and Van Vegan state; In the second generation (the second half of the 1960s to the mid-1970s), with growing criticism of the resulting failures, attention shifted to social solutions; During the third generation (mid-1970s to 1980s), the design methods movement was coming to an end; Alexander was strongly opposed to labeling any idea with the title of methodology. In the fourth generation (from the 1990s to the present), attention to information processing systems and decision support systems in design has increased dramatically. The design process can include hypothesis and hypothesis testing, but it cannot be expressed in the form of a cause-and-effect relationship, rather this process works relatively with the relationship of change and disturbance.

Professional design almost always involves a combination of intuition and a systematic approach. Today, design is more than an individual activity of a designer, it is a process that will involve a large number of people [16].
In architecture, the human factors in design cannot be ignored or denied. In design, the role of the legislator, user, employer, and designer should be considered in the design process [17]. As mentioned before, the role of man and laws is very important in the field of architecture, in architectural design, the laws that are explained in order to ensure the comfort and safety of users, are provided in the form of functional requirements with the help of physical building elements and components, which are important factors. are in design; In Fig 2, the effective factors in the design process in the field of architecture are presented.

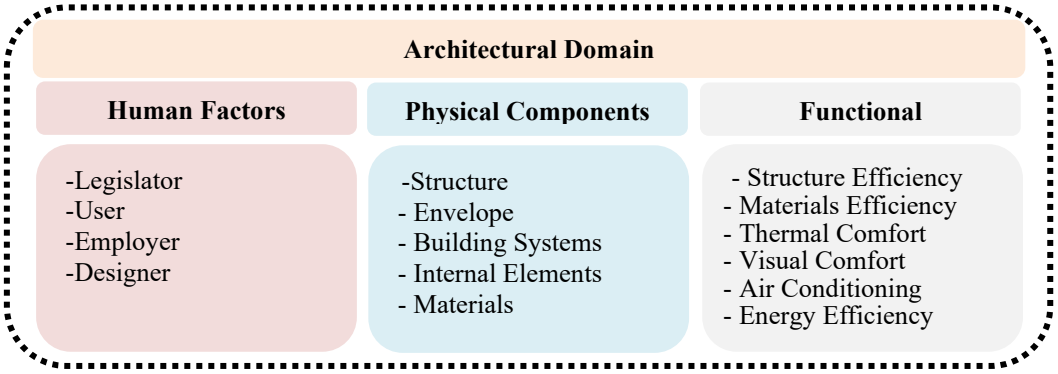


Fig 2: Effective factors in the architectural design process

By studying the achievements of experts [18] in order to provide a model for the design process, witness their consensus on the non-linearity of the design process and their participation in the four stages of Problem discovery and expression, Data analysis, and combination, Problem-solving and Validation (Fig 3). It is very difficult to categorize the importance and necessity of the four mentioned stages because these four stages are the most basic elements of the design process and without receiving and understanding each stage correctly, there will be deficiencies and disturbances in the next stage as well. It is important to use existing knowledge as a basis for new ideas.

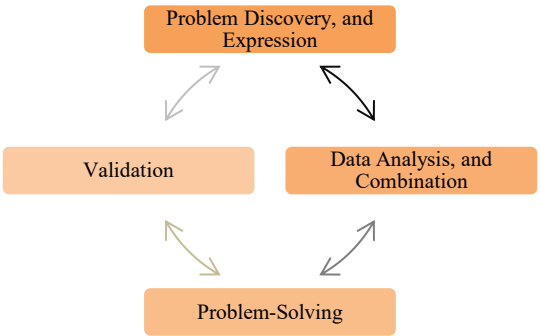


Fig 3: The consensus of experts on the non-linearity of the design process and their participation in the four stages

The use of nature as a source of inspiration is popular in architecture. Different methods of comparison with nature have been categorized in different ways by other researchers. Qiyabeklu considers the different methods of using nature as a form imitation, material imitation, construction method imitation, process imitation, and function imitation at three levels of structure and organs of living beings, individual behavior and ecosystem, and group behavior [19]. Sharqi and Qanbaran introduce three ways of inspiration from nature: nature's forms, nature's meaning inspiration, and nature's rules inspiration [20]. Khakzand and Ahmadi state that the method that leads to the presence of the spirit of nature in architecture is better than the formalistic methods [21]. Emphasizing learning from nature rather than copying forms, Nachtigal states that "Outer Form"

plus "Inner Life shape" performance. Pure formalism does nothing for technology. Nature forms are always functional and have a task [22]. There are two inductive and deductive approaches related to analogy from nature: the inductive approach starts with a design problem and designers look for suitable analogies in nature to answer it [23]. The inductive approach begins with the study of nature and its structures, and then the information is documented and possible answers are generated based on the patterns of nature to be used in design issues in the future [24]. In research in the analogy design field, two methods of structural analogy (inspiration from structures and functions in nature) and surface analogy (inspiration from surface characteristics such as colors and shapes) have been mentioned [25]. To achieve the structural analogy, the connections between the sample components (structural features) should be summarized and the transfer activity should be accompanied by the transformation. Only the transfer between components or the relationships between components alone is not enough, transformation must also take place. The designer must make changes to fit the context of the target situation [26]. Emphasizing the importance of summarizing the existing functions in nature, Nachtigal and his colleagues suggest the process of searching, summarizing, transforming, and applying to understanding natural phenomena [27]. Therefore, structural analogy means summarizing the structural features, transforming and adapting to the needs of the new design. In other words, transferring the structural features of the source of inspiration to the structural features of the new design, which is accompanied by summarizing, transforming, and adapting. Metaphors can be considered as another type of analogy that creates meaning and perspective about the design problem but does not convey characteristics [28]. Therefore, the methods of using nature in design in our beloved country of Iran are summarized in the following three categories:

1. Superficial analogy: taking advantage of the appearance and form features in natural phenomena;
2. Structural analogy: taking advantage of structural and functional features in natural phenomena;
3. Conceptual analogy (metaphor): indirect reference to concepts in natural phenomena [29].

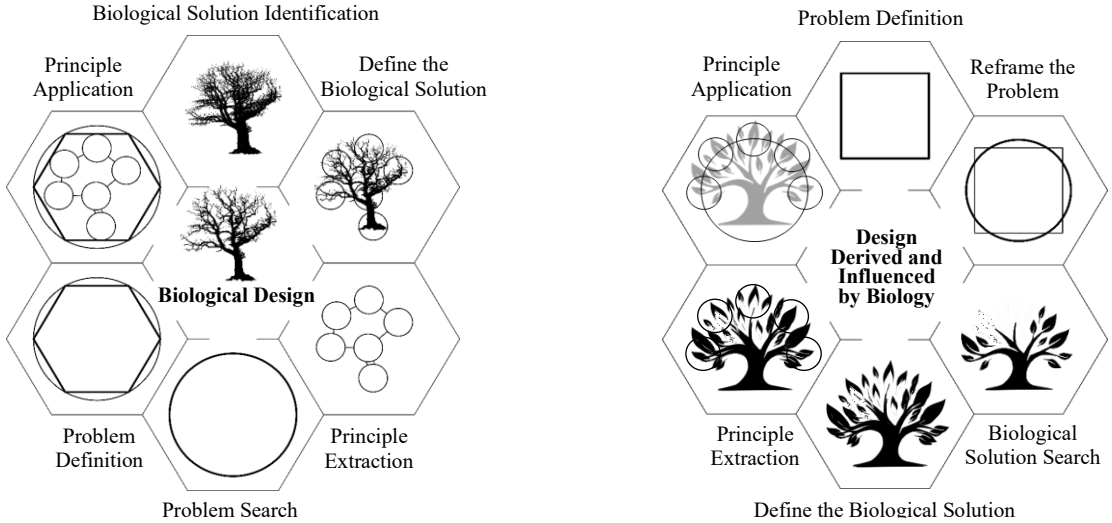


Fig 4: Problem-solving approaches influenced by biology. (Source: based on Harris, 2016, 6-7) [33]

Today, the design process using nature's strategies can be defined based on two approaches, which are: the problem-based approach, which is also called the top-down approach, and the solution-based approach, which is the bottom-up approach. Although these attitudes have different names, they all refer to the same meaning [30]. Michael Helms and his colleagues at the Georgia Institute of Technology defined a "Problem-based and Solution based" approach in six nonlinear, dynamic levels, where each output affects previous phases and provides feedback loops [31]. Zari calls it "design following biology", she considers nature full of solutions that designers with the help of

biologists or with the knowledge of biological sciences can identify and discover these solutions. By taking advantage of the methods that organisms in nature use to solve problems, they learn from them and adapt and use those solutions to solve human problems [32] (Fig 4).

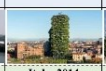
2. Discussion

Although there have always been various intellectual roots and approaches centered on nature and architecture, none of them have reached a significant result.

Also, the research carried out to achieve a sustainable built environment only at the initial levels and with the implementation of few components and in a limited way has solved the problem with the approach of using nature-inspired design strategies; In case, a deeper view of the subject has been required so that planning and development of a sustainable environment based on the patterns taken from nature and using them has been achieved. In this regard and according to the initial research results, there was no specific method to effectively use nature-inspired design strategies in sustainable built environment development projects.

In order to gain a deep insight into the method, attitude, tools, and effects of using "nature strategies in architecture", logical argumentation and case study have taken place (Table 2).

Table 2: Logical argumentation and case study of expert's project (Source: Authors based on Aamer et al, 2020, 13) [34]

	Project / Study Criteria, and Analysis		Score	P_1 Eastgate center Zimbabwe by Mick Pearce	P_2 Arts Centre by Atelier One, DP Architects, Michael Wilford &Partner	P_3 The Savill Building, designed by Glenn Howells Architects	P_4 Media-TIC by Cloud 9 (Enric Ruiz Geli team)	P_5 Theme Pavilion Expo Yeosu by SOMA Lima	P_6 Torre del Bosco by Stefano Boeri Architetti	P_7 Italy Pavilion by Nemesi & Partners	P_8 Eye-Beacon Pavilion by unSTUDIO	P_9 Amazon in the Regrade by NBBJ	P_{10} EAN building by William McDonough + Partners
													
				Zimbabwe-1996	Singapore-2002	UK-2005	Spain-2010	South Korea- 2012	Italy- 2014	Italy- 2015	Netherlands- 2017	America- 2018	Colombia- 2021
	The Organism's Role and Characteristics			Termite, Cactus	Durian fruit	Seashell	Box jellyfish	Strelitzia Reginae	Forest	Tree Branch	Bioluminescence	The Substrate Ecosystem	Foliage Leaf
Nature Inspired Design Strategies Domain	Attitude	Solution-based approach	✓					✓	✓			✓	
		Problem-based approach	✓	✓	✓	✓	✓			✓	✓		✓
	Dimensions of strategy	Characteristic of the organism	5	5	5	5	5	5	0	5	0	0	0
		Social relations of the organism	5	0	0	0	0	0	5	0	5	0	0
		Ecological relations of the organism	5	0	0	0	0	0	0	0	0	5	5
	Levels of strategy	Form	5	5	5	5	3	5	0	5	0	3	5
		Material	5	0	0	5	3	3	0	0	0	0	0
		Structure	5	5	0	0	5	0	5	0	0	5	5
		Process	5	0	0	0	5	3	5	5	5	5	5
		Function	5	5	0	5	5	5	5	5	5	5	5
Architectural Domain	Building capability- Functional Requirements (Target)	Structure efficiency	5	3	0	0	5	3	5	5	5	0	5
		Materials efficiency	5	0	0	5	5	3	0	5	0	0	5
		Thermal comfort	5	5	3	0	5	5	3	0	0	5	5
		Visual comfort	5	0	5	5	3	5	5	5	5	5	5
		Air conditioning	5	5	0	0	5	5	5	5	0	5	5
		Energy efficiency	5	5	5	5	5	5	5	5	0	5	5
		Water quality	5	0	0	0	0	0	0	0	0	0	0
	Building capability - Physical components - (Elements)	Structure	5	5	3	5	5	0	5	0	5	5	5
		Envelope	5	0	5	0	5	5	0	5	5	0	5
		Building systems	5	5	0	0	5	5	5	0	0	5	5
		Internal elements	5	0	0	3	3	0	0	3	5	5	0
		Materials	5	3	0	5	3	5	0	5	5	0	5
Valuation			100	٪ 51	٪ 31	٪ 48	٪ 75	٪ 67	٪ 53	٪ 58	٪ 45	٪ 58	٪ 75

Investigating the effect and transfer of nature-inspired design strategies in the field of architecture (investigation of methods and tools) and also investigating the type of attitude and method of designers in using nature-inspired strategies to transfer and apply the strategy in the architectural process (transfer of nature-inspired strategies to architecture) has been done. It is presented in the form of table 2, Fig 5,6,7, and 8. This research includes two main studies, each of which includes several cases; which provided the context for explaining the use of nature-inspired strategies in the architectural design process based on the analysis of studies. In addition to focus groups (Participant Observation) with the statistical community of students, the studies of this section were conducted in order to examine the similarities and differences of these results with the professional world of architecture and thus increase the validity and reliability of the research

results (Fig 6). The findings of the logical argumentation and Case study confirm the results of the focus group survey with the statistical population of students. This issue calls for the necessity of building a culture of teamwork and also paying more attention to the utilization and use of experts in various fields such as biologists, psychologists, architects, civil engineers, and in short, according to each design problem and design approach of the relevant experts in those fields, which form the design group of that project.

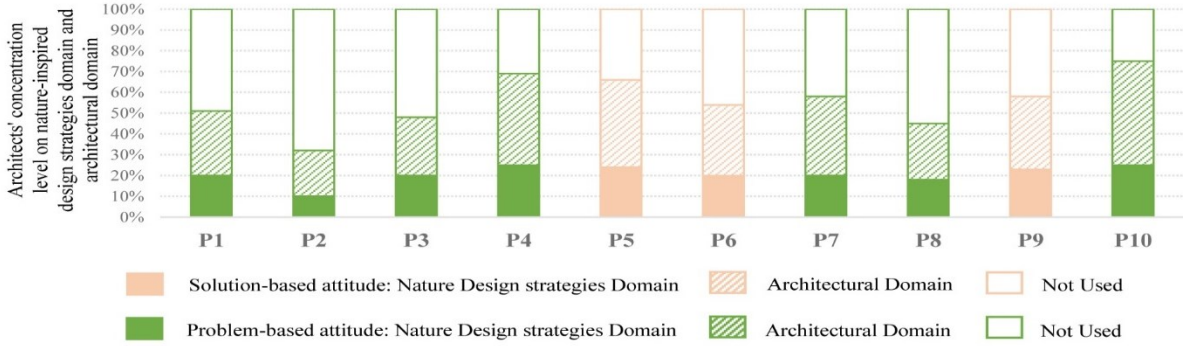


Fig 5: The level of using nature-inspired design strategies in ten selected expert projects

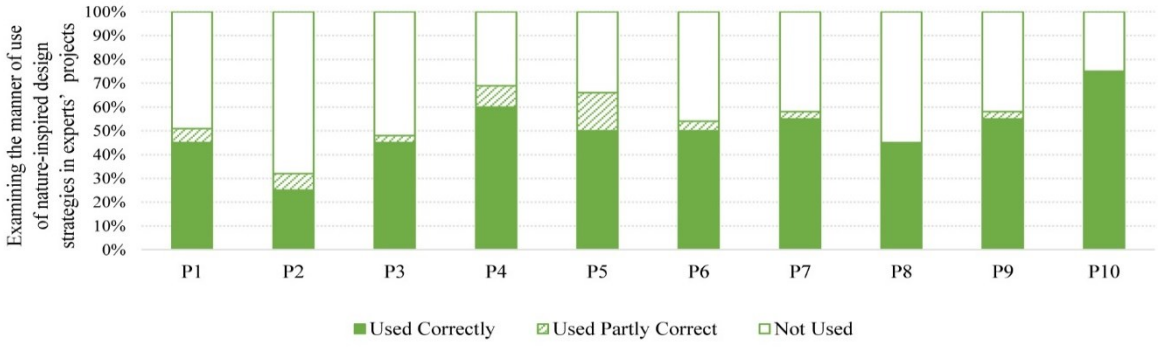


Fig 6: Examining the attitude and architects' concentration level on nature-inspire design strategies and transferring them to the architecture solution

After studying ten projects, four projects with the highest scores were selected for deeper study. The design process and the method of using nature-inspired strategies in each project were examined (Fig 7).

Based on this, studying the characteristic of the Organism, Social Relations of the Organism, and Ecological Relations of the Organism, each of which has five levels of form, material, structure, process, and function, can be used. To imitate similar functions two main attitudes have been explored which are the Problem-based and Solution-based approaches. In a problem-based approach, design is grounded in biology; In the sense that a human problem or need is created first, and then designers, in cooperation with biologists or by using biological databases to find a solution, examine nature and identify the solution in the heart of nature, and that solution with the organisms that They have solved a similar problem. This approach is effectively directed by designers to identify primary goals and design parameters.

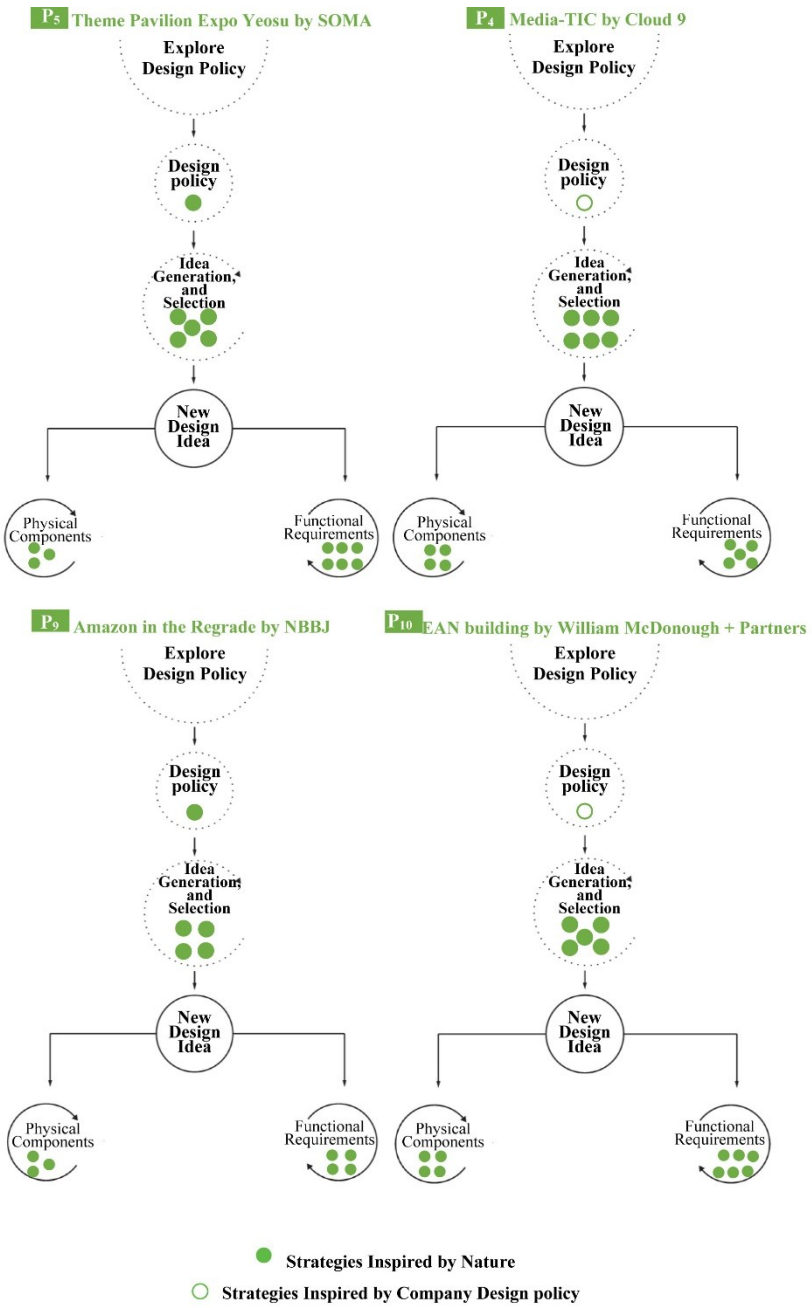


Fig 7: Comparing the effects of nature strategies on the concentration level of experts in the top 4 projects

This means that biological studies are done after examining and categorizing human problems and limitations and functional requirements, which means that first the initial design policy is formed according to human factors and functional requirements, and then following the biological studies according to the initial design policy The general design policy is explained. In the next phase, according to the general design policy, the nature-inspired strategy is identified and as a result, the life principles are selected, after selecting and determining the biological principles, these principles are fully examined in different dimensions and biological levels, in such a way that It is possible to form the foundation and basis of the plan based on the extraction, separation, and classification of biological information, and in the next phase, by coding the classified information, they can be simulated and some suitable prototypes can be produced and presented. In a solution-based approach, the design process depends on biological knowledge and research, rather than specific design problems; Biology influences the design, in the sense that the biological source and the life

principles are first identified and selected, and then thoroughly examined in different biological dimensions and levels, in such a way that it can be properly used as the foundation and basis of the design. This means that in this phase, biological information can be extracted, separated, and categorized first, and in the next phase, it can be simulated by coding the categorized information.

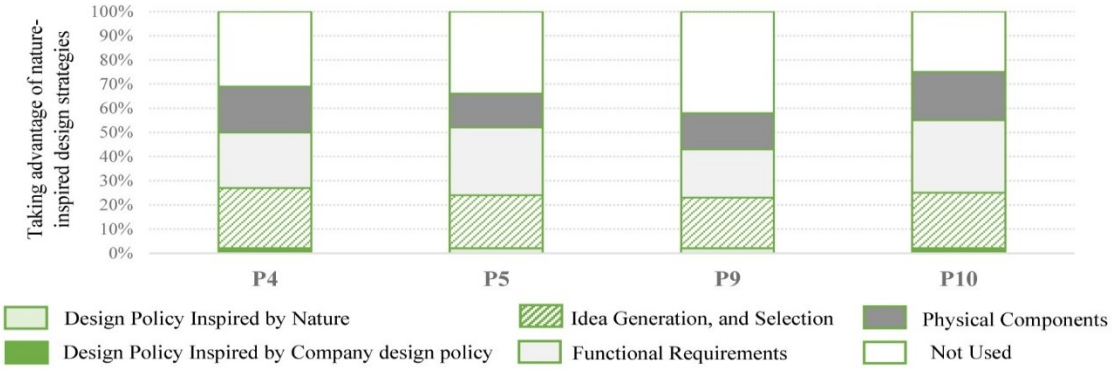


Fig 8: Comparison of the use of nature-inspired strategies in the four main phases of the architectural design process

3. Conclusions

The results indicate that designers and architects by studying and understanding nature-inspired design strategies and using the resulting knowledge can use them to achieve environmentally compatible built environments and sustainable systems, as a result, achieve a symbiosis between the built environment and nature. It is also possible to achieve new technologies in various fields to solve human problems. The more similar the systems, functions, and human-made creations, in general, are to the natural world, the more likely they will survive longer. This is a special concept and a more comprehensive approach to achieving environmentally friendly and sustainable spaces. In addition, the results indicate that in this comprehensive view, life and nature should be considered in connection with each other and not separate from each other, of which man is also a part; As a result, in the direction of their connection and integration, it is necessary to identify the obstacles and components that cause the separation and non-alignment of man and nature. What was obtained from focus groups, logical argumentation, and case study shows the importance of addressing all three dimensions, "characteristic of the Organism, Social Relations of the Organism, and Ecological Relations of the Organism" and the sciences were hidden in them in the form of five levels "form, materials, structure, process and function" (Fig 9).

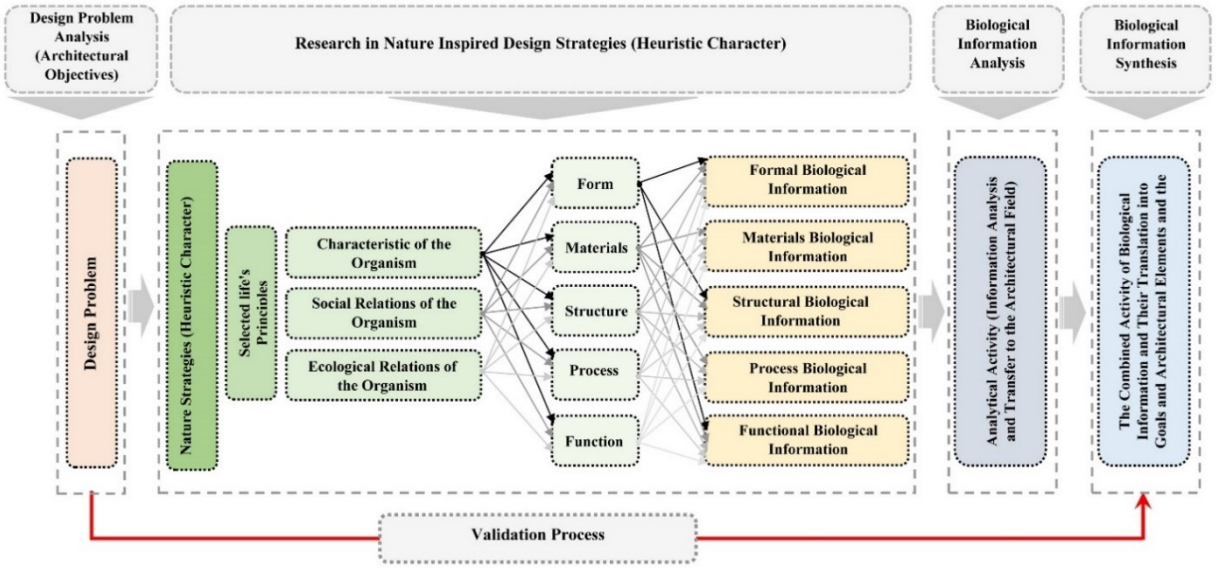


Fig 9: The effective components of nature strategies in the architectural process

By carefully studying the five mentioned levels in the three dimensions that constitute the life principles, one can obtain key elements, information, and parameters that, by understanding, translating, and using them correctly, expand the boundaries of the architectural domain and in addition, take a long step in the direction of survival, sustainability and Creation of artificial spaces compatible with the environment.

Investigating the effects of using nature-inspired design strategies in the architectural process indicates the significant effects of nature's strategies in improving the theoretical and practical scope of the architectural design process. The influence of nature's strategies on the architectural design process in both practical and theoretical areas is compared in Fig 10 in four steps with an explanation of the characteristics of each step.

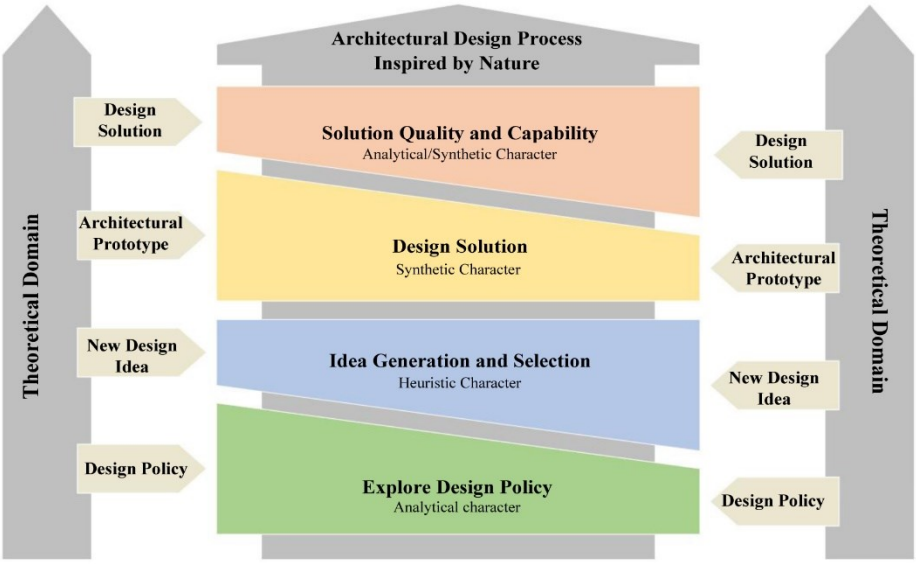


Fig 10: The effects extent of using nature-inspired design strategies in the architectural process in the theoretical and operational domain

The effectiveness of nature's strategies in the step of Explore Design Policy, which also has an Analytical character, is more in the practical domain than in the theoretical domain, while the results indicate a more significant effect in the step of Idea Generation and Selection, with an exploratory nature, in the field of It is an opinion about the practical field; This means that taking advantage of the science hidden in nature and studying it has a meaningful and effective effect in expanding the range of information, as well as establishing better communication between the designer, the design subject, and the user, and as a result, new design ideas have a more diverse and innovative range with an increase in the harmony between the natural substrate and the built environment. In the third step of architectural creation, where the designer seeks to provide a solution in the form of presenting a prototype, it can be acknowledged that the designer presents his architectural prototypes by combining architectural goals and strategies that he discovered and extracted from the study of nature's strategies, according to the results from the research, it can be acknowledged that the effect of nature's strategies in this step is more on the practice field. In the final step, which is the presentation of the most appropriate solution and the evaluation of the building's quality and capability to align and adapt to the design goals, more impact has been seen in the theoretical field. This significant difference can be reported as a result of the complexity and multiplicity of the architectural requirements of the practical field compared to the theoretical field, because in this field, the designer in real interaction with human factors, is necessary to coordinate and harmonize the functional requirements and the explained limitations of human factors.

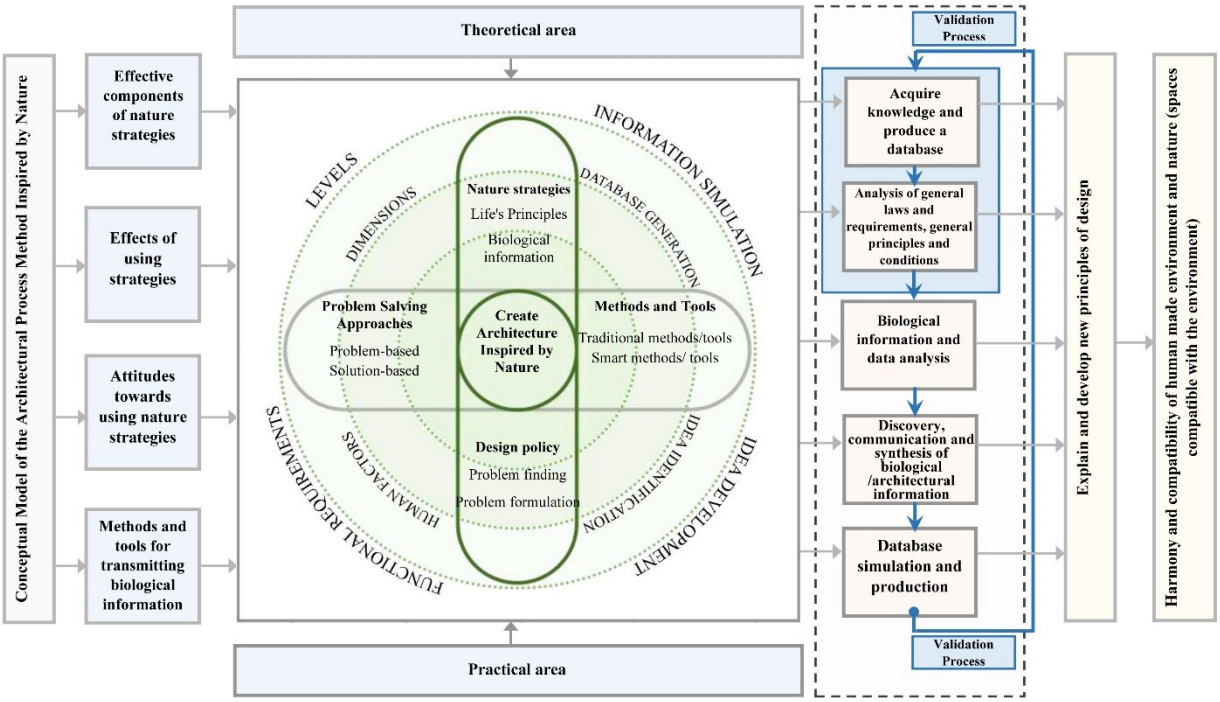


Fig 11: Nature Strategies in Architecture Design Process Towards Nature and Built Environment Symbiosis

The analysis of the research findings shows that the biological study and the use of nature's strategies increase the level of concentration and attention to wider dimensions and the effective components' level; In the co-construction of architectural elements. Also, in the focus groups, students architectural design process has been done with a clear and systematic vision, which improved the project's quality, improved the variety of innovative ideas. The appropriate selection of nature's strategy based on the design problem and examination of life principles at different levels in all three biological strategy dimensions is vital in achieving a product that is compatible with the environment. As shown in Fig 11, the architectural design process inspired by nature is a dynamic process with an analytical, heuristic, and synthetic Character.

The design process goal is to find the most suitable and best possible solution. Phase one follows problem finding and formulation of the problem, and its scope is expanded without any limitations with the purpose of finding the truth, collecting information, and creating a database; In the second phase, all the obtained information should be analyzed and refined to identify and extract suitable propositions; Next, in the third phase, it is not only designers and architects who work, but they are also placed next to a team of engineers and biologists, and the prototypes are simulated and evaluated by the engineers in textual or visual programming environments; Finally, the fourth phase is the final test of the prototype, so that the final evaluation of the prototype is done to ensure their compliance with the building capabilities such as structure, building system, shell, internal elements and materials, and the best option is selected as the final solution.

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