



Practices of Biophilic Patterns in Workplace Design

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Abstract; Nature-based design strategies for indoor environments as an efficient approach for improving workplaces design and employee's health and wellbeing have received little attention compared to other design strategies related to comfort and wellness concepts in workplaces including office ergonomics, thermal comfort, lighting conditions and acoustic factors. The paper focuses on biophilic design as an effective approach for enhancing workplace design and promoting employee's health through the application of nature-based design solutions. The study provides insights into the implementation of biophilic design patterns in workplace design through studying international examples successfully adopting this design approach. Inputs about the biophilic theoretical background and related health benefits are also discussed to better understand the user's positive responses to nature. This paper proposes a series of tools to be incorporated in actual design practice of workplaces design aiming to reconnect users with natural environments thus benefiting from it in terms of cognitive, psychological, and physiological health outcomes. These tools can be classified into elements related to interior design, building design, and outdoor spaces design that can be included in further practices of workplace design.

Keywords: Biophilia, biophilic design, restorative theories, health benefits, workplace design

Introduction

The world of work is changing presenting an opportunity for workplaces design to change as well to optimize worker performance and productivity. Spending long hours in traditionally designed office workplaces overusing our mental effort to perform tasks has grown the need to address health, wellbeing, and productivity in these spaces. Hence, the change in workplace design more recently is not just limited to office

layout but it is also perceived in the introduction of comfort and wellness concepts into workplace design. Biophilic design is one emerging approach that contributes to the mental and physical wellness of its users through introduction of natural elements in space design that enhance human connection with nature [1].

Workplaces that incorporate elements of nature can ensure for workers high levels of

wellbeing, mental restoration, reduced stress, and enhanced cognitive performance in addition to boosting their productivity[1]–[3]. This can be explained through the biophilia hypothesis which demonstrates the inherent human inclination to affiliate with nature[4], [5]. This paper presents some theories that helped in translating human's positive psychological and physiological responses to nature into a set of design practices called biophilic design patterns that provide several health benefits for users. The paper aims to retrieve design strategies for applying the biophilic approach efficiently in workplaces design via understanding the concept of biophilic design patterns according to Terrapin Bright Green definition and categorization and via exploring and analyzing its application in terms of workplace design to recognize how the designers can implement this approach successfully in a manner that support employees' health and productivity in turn.

2. METHODOLOGY

In order to achieve the mentioned aims, this paper firstly conducts a literature review about the theoretical background behind the emergence of biophilic design and that provides the evidence of the link between nature and improved wellbeing. The benefits of biophilic design for human health are then discussed to justify the benefits and positive impacts of introducing this design approach in space design, followed by an analytical study presenting international examples of workplaces that best demonstrate successful design interventions for each biophilic pattern.

This analysis concluded in identifying key aspects of biophilic design application that offer an efficient design guide to be applied in further workplace design.

3. THEORETICAL PERSPECTIVE

A great body of research has arisen to demonstrate the interdependency of human health and wellbeing and the natural world based on the biophilia hypothesis that describes the human's innate biological connection with nature which developed during the process of human evolution[4]. This led to the development of theories pertaining to biophilic design and relevant to its principles and that guide us how it can be incorporated in an effective way that re-introduce nature into the built environment.

These theories can be cited as the attention restoration theory (ART) that suggests that nature restores mental capacity [6], and the stress reduction theory (SRT) that states that nature recovers from stress [7]. Moreover, the prospect-refuge theory that argues that most preferred environments are those who achieve balance between both prospect and refuge similar to natural environments [8], whereas the savanna hypothesis states that human prefer Savannah-like landscape than present cityscape [9], and finally the ecological valence theory that suggests that people seek colors that are relevant to thriving nature [2]. Fig 1 describes the process of translating biophilia into biophilic strategies within space design in relation to these theories:

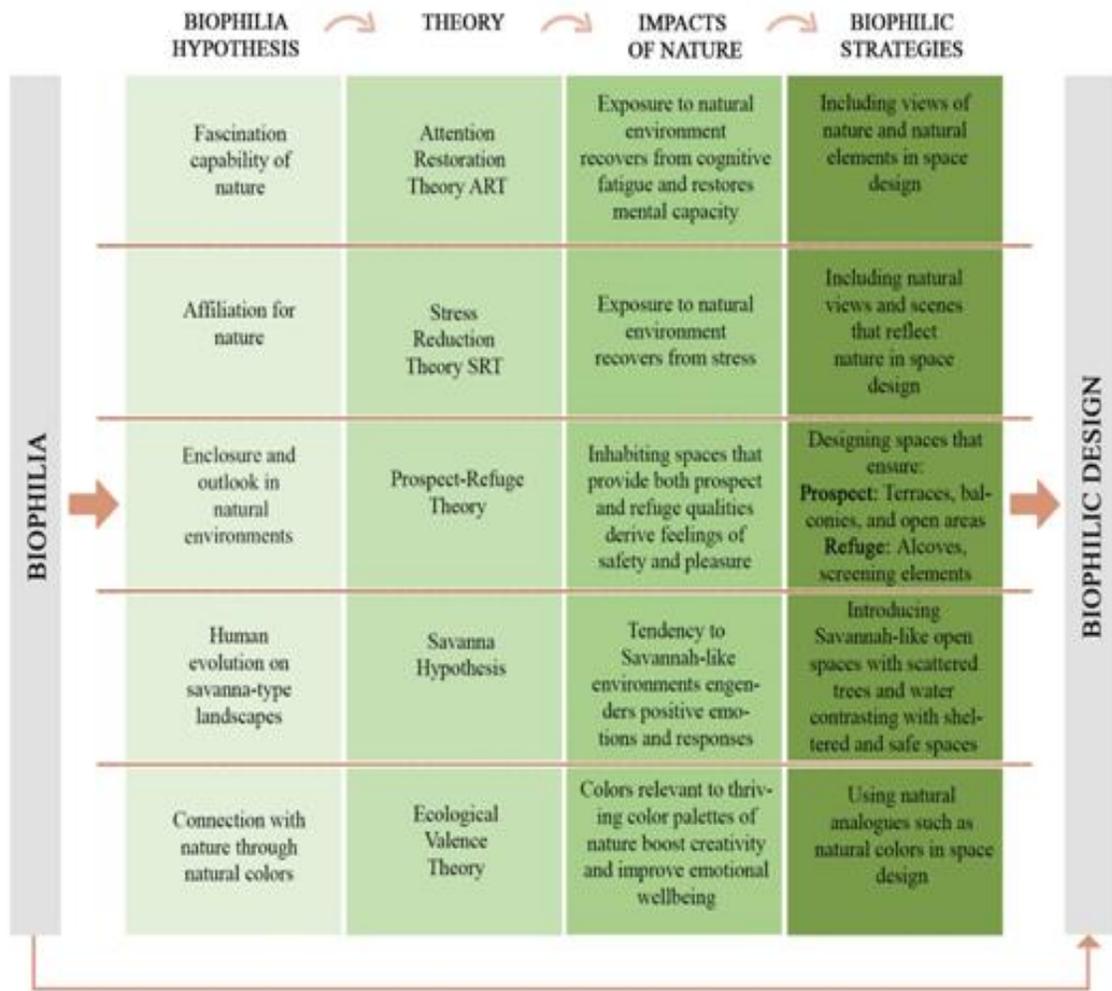


Fig 1. The process of translating biophilia hypothesis into biophilic design

4. Health benefits of biophilic design

The mentioned theories presented positive human responses to nature related to enhanced wellbeing and health outcomes for inhabitants. Hence, the biophilic approach– that aims to re-introduce nature in the built environment – is applied most recently as a complementary design strategy in several building types including the workplace design where office workers report improved creativity, productivity and wellbeing in spaces that feature connection to nature[3]. Terrapin Bright Green in their report ‘14 Patterns of Biophilic Design’ noted that the human-related benefits of this design approach are divided into three broad mind-body systems:

4.1 Cognitive Functionality and Performance

Cognitive functioning refers to mental abilities including thinking, remembering, learning, decision making, problem solving and attention [10]. To perform cognitive processes on repetitive tasks, we need to allocate our attention in a directed manner, this is called directed attention [11]. Directed Attention is energy intensive and overusing it causes mental fatigue and depleted cognitive resources [3]. Walking in nature or viewing pictures of nature improve directed attention abilities and allow it a chance to replenish as it is filled with intriguing stimuli that gently grabs our attention [12]. Attention restoration theory as well demonstrates that nature

provides us with moments of mental restoration resulting in improved cognitive functions and better capacity for performing focused tasks[6].

4.2 Psychological Health and Wellbeing

Psychological wellbeing includes reduced stress, improved mood, and emotions. Many studies have shown the evidence of positive effects of nature in terms of specific psychological conditions such as depression, anxiety, and mood disorder[13]. Virtual and direct relation to nature improve psychological restoration which is the ability to overcome stress and mental fatigue and experience the mental rejuvenation [14]. Furthermore, visiting or viewing a forest scene has a greater positive outcome on psychological healing and wellbeing regarding recovery from stress, improved concentration and productivity, and improved psychological state than urban environments with limited characteristics of nature [15].

4.3 Physiological Health and Wellbeing

Physiological Health refers to aural, musculoskeletal, respiratory, circadian systems and overall physical comfort[3]. Being in nature or viewing natural scenes contribute as well to better physiological responses in terms of reduced blood pressure, heart rate deceleration, reduced muscle tension, improved brain electrical activity, and management of the production of stress hormones[7]. Stephen Kellert demonstrated that the successful application of biophilic design result in several positive physical impacts including enhanced physical fitness, fewer illness symptoms and improved physical health resulting in enhanced performance and productivity [4].

5. APPLICATION OF BIOPHILIC PATTERNS IN WORKPLACE DESIGN

This section aims to define biophilic patterns according to the definition of Terrapin Bright Green and Oliver Heath [3], [8] and to study the suitable architectural intervention for each biophilic pattern in terms of workplace design. International examples are classified under the main categories of biophilic design to study how biophilic patterns can be

implemented successfully within the workplace design to achieve fruitful outcomes:

5.1 Nature in the Space

The *Nature in the space* category includes the patterns that represent direct and physical presence of nature in the space, which can be achieved through adding natural elements to the built environment. This is the easiest yet most effective method to introduce the biophilic approach to workplace design:

5.1.1 Visual Connection with Nature [P1]

This pattern is defined as viewing elements of nature, living systems and natural processes going from viewing a natural view, adding water features to experiencing natural airflow, sounds and scents. Strategies for applying this pattern in the workplace can be identified in implementation of indoor plants illustrated in landscaping of trees and bushes, potted or hanged plants, green walls, etc. Beside adding an aesthetic value to the space, plants purify air from pollutants resulting from carpets and new furniture which improves indoor air quality[16], additionally it absorbs ambient noise and reduce acoustical distractions [17].

The biophilic pattern can also be applied through including full height windows that maximize access to outdoor natural views and that flood the workplace with daylight as shown in Fig.2. Roof terraces and outdoor gardens ensure direct contact with nature as well and ensure a space for employees to perform individual tasks, to gather or to take a break while contemplating natural beauty as shown in Fig.3. However, some workplaces lack access to outdoor views and tend to depict natural sceneries of plants motifs, mountains, or oceans



FIG 2. Indoor plants and full height windows in Supermetrics offices, Finland[18]



FIG3.Rooftop at Interface Headquarters, Atlanta[19]

5.1.2 Non-Visual Connection with Nature [P2]

The pattern can be defined as experiencing sounds, touch, tastes, and smells that engender positive reference to nature aiming to stimulate all human senses via exposure to references to nature. There are many applications that relate to this pattern including the biophilic soundscape as shown in Fig. 4 which is mimicking sounds of nature to help employees focus better on their tasks especially in open floor plans where arise acoustical distractions [20]. The sense of touch can be stimulated as well through experiencing and touching natural materials used in the design of the workplace such as wood, stone, marble, etc., as shown in Fig.5. Also, the senses of smell and taste can be stimulated through growing local flowers and herbs that release natural scents or fruits and vegetables.



FIG 4.Sensors emitting the sound of birds at Prudential WorkPLAYce[21]



FIG 5.The use of natural textures at Uncommon's workplace[22]

5.1.3 Non-Rhythmic Sensory Stimuli [P3]

The pattern refers to consistent, yet unpredictable objects and materials found in nature. Unpredictable moments of nature allow employees to distract for instance from performing focused tasks which reduce mental fatigue because nature offer us moments of effortless attention [6]. Momentary exposure to nature can be experienced through operable windows or through access to outdoor spaces such as rooftops or terraces.

5.1.4 Thermal and Airflow Variability [P4]

The pattern aims to mimic the environmental conditions found in nature where human experience changes in temperature, humidity, and airflow which is important for employees' comfort and physical health [23]. The basic application of this pattern is including sun blinds that protect users from hot climates and operable windows or roof terraces and outdoor working areas that allow access to fresh air. Furthermore, applications of the pattern are extended to more advanced window treatments such as controllable façade-glass louvers that ensure varying temperatures all over the space to enhance thermal comfort of users as shown in Fig. 6.

Beside addressing thermal variability, several biophilic applications address airflow variability to improve indoor air quality for employees. Such applications can be illustrated as implementing airflow sensors that control airflow levels all over the workplace to enhance employees' attention on focused tasks, in addition to including active air walls – shown in Fig. 7 – that remove air pollutants by drawing fresh air from roots and leaves which improve air quality.



FIG 6.Controllable façade-glass louvers at Hankook Technoplex[24]



FIG 7. Atrium green wall at Centrica Office, Oxford-UK[25]

5.1.5 Presence of Water [P5]

Presence of water include experience of hearing, seeing, or touching water because being near water arise feelings of tranquility and reduced stress. Implementation of water fountains, water walls and aquariums are common applications of this biophilic pattern, and beside adding an aesthetic value, they can be applied for a functional reason which is masking ambient noise in workplaces. In case of the complexity of applying such features, images depicting water in nature can be efficient.



FIG 8. Small islands-like meeting rooms sunken in a pool of water [26]

5.1.6 Dynamic and Diffuse of Light [P6]

This pattern reinforces our connection to varying intensities of natural light and shadows that change to simulate conditions that occur in nature. The exposure to daylight in workplaces can be achieved via incorporating full height windows, atriums, and skylights which maintain circadian systems. Additionally, advanced technologies such as occupancy light sensors and switchable opaque glass walls ensure exposure to dynamic diffuse of light in the workplace. Moreover, including wall installation or façade skins that createdynamic conditions of lighting

and dramatic shadows in the indoor space are a common application of this pattern as shown in Fig 9.



FIG 9. Leaf wall installation at Sanofi office, Dubai[27]

5.1.7 Connection with Natural Systems [P7]

This pattern aims to raise the awareness of seasonal and temporal natural processes and to connect people to changes that occur in nature. Integration of the pattern in workplace design can be illustrated in including full height windows, rooftop gardens, courtyards, and office patios that allow employees to notice outdoor plants that grow and die with seasons in addition to other natural life cycles as shown in Fig. 10. It can be applied also through implementing mechanical systems dependent on processes occurring in nature such as rainwater, solar radiations, and wind breezes; such systems can be cited as rainwater collection systems, solar photovoltaic panels, or electricity systems.



FIG 10. Office patio that allows awareness of seasonal changes in nature[28]

5.2 Natural Analogues

The *Natural analogues* category presents the patterns that refer to indirect simulation of nature through implementing man-made elements that mimic nature in the built environment which trigger the same feelings as being in the natural environment:

5.2.1 Biomorphic Forms and Patterns [P8]

Biomorphic forms and patterns give a symbolic reference to patterned or textured arrangements found in nature; it is often applied in fractals, natural patterns, and fluid and organic forms of design elements of the workplace as shown in Fig. 11. Fluid and organic forms found in nature can also be applied to other design elements such as furniture pieces and wall partitions as shown in Fig. 12.



FIG 11. Tree-like structure at ATXK Office[29]



FIG 12. Organic working area at Open AD office[30]

5.2.2 Material Connection with Nature [P9]

Another way of indirect simulation of nature in the workplace is the selection of materials and elements of nature that reflect local ecology or geology to create a sense of place such as wood, stone, marble, etc. in floorings, wall cladding and furnishing – shown in Fig. 13 – that help in reducing the release of chemicals and toxic emissions that impact air quality [31]. The biophilic pattern can also be achieved through selection of color palettes inspired from nature in design such as earthy shades, blue and green tones that are most synonymous with nature as shown in Fig. 14.



FIG 13. Wooden material selection in ceiling, desks and flooring at Hortonworks office[32]



FIG 14. Workplace using colors inspired from nature (green, blue, and yellow)[33]

5.2.3 Complexity and Order [P10]

The concept of complexity and order arises from the rich sensory information found in nature in complex fractal and geometrical patterns of natural forms. The objective of this pattern is to include fractal patterns, symmetries, and complex configurations in the built environment similar to those found in nature. Basically, these applications can be found at varying scales in workplace design going from carpets textures, modular floorings, and partitions to complex building skins and exposed structural and mechanical systems as shown in Fig. 15.



FIG 15. Patterns applied into floorings and partitions at Nordea Seaport office[34]

5.3 Nature of the Space

The *Nature of the space* category presents the patterns that replicate the feelings nature give us. These patterns are based on the concept of human evolution in nature and the feelings he had beyond the immediate surroundings where he evolved in:

5.3.1 Prospect [P11]

The prospect pattern is defined as providing unimpeded views over a distance for surveillance and planning relating it to open design. Prospect in workplaces can be achieved through several design strategies; one of them is the open plan space layout. Additionally, transparent materials and see-through partitions are also an evident application of prospect pattern in workplace design as it allows employees to survey whether their surrounding or the natural outdoor environment. Access to rooftop and balconies for surveillance and elevated planes are a common application of prospect pattern as well as they give the user the ability to survey his surroundings as shown in Fig. 16.



FIG 16. Terraces and bridges give prospect views at Amazon Spheres[35]

5.3.2 Refuge [P12]

The refuge pattern aims to survey and look over the surrounding environment but from a withdrawn place protected from overhead and behind which provide users a private space all along with being able to observe the surroundings; these private spaces help them to maintain their energy levels. A refuge space can be indoor such as telephone pods, private nooks, recharge rooms and swing seats as shown in Fig. 17 or a semi-open outdoor place. Implementation of furniture forms that ensure both enclosure and privacy is an additional strategy for the refuge

pattern as it provides a protected and private zone within the open plan workplace as shown in Fig.18.



FIG 17. Private spaces for work or relaxation at Adobe HQ, California[36]



FIG 18. Freestanding partitions to ensure isolation and privacy[37]

5.3.3 Mystery [P13]

The mystery pattern consists of partially obscured views that stimulate user's excitement and sense of exploration which allow him to travel deeper into the environment. Curved walls and see-through partitions are common applications of the mystery pattern in workplace design because they stimulate the employees to explore the whole space as shown in Fig. 19. Designers of workplaces recently tend to add way finding paths on floorings to guide employees to navigate through the workplace fluidly shown in Fig. 20, these paths represent an interesting visual map that creates a sense of mystery and that helps employees to explore the space on their own.



FIG 19.Curvilinear walls at Zhen Fund Office, China[38]



FIG 20.Highlighted travel paths at DoorDash HQ[39]

5.3.4 Risk/Peril [P14]

The risk pattern is defined as unidentified threats coupled with a reliable safeguard. Perceived risk feelings can be fear of falling, getting wet or hurt, and losing control[3]. Installation of full height windows, transparent railings, double heights, and cantilevers provide feelings of risk from falling as shown in Fig. 21. Office hammocks is an innovative trend introduced recently in some workplaces design to offer employees a flexible and private space to relax or to perform a personal task as shown in Fig. 22. These hammocks can be installed over a double height to support the risk pattern



FIG 21. Double heights and cantilevers at Amazon Spheres[40]



FIG 22.Hammock as a relaxation space at Kong Rex Office, Brazil[41]

6. DISCUSSION

Key aspects of biophilic interventions at different scales of workplace design can be retrieved from the analysis of the mentioned examples, offering a design guide for applying various biophilic strategies in the working environment to achieve healthier and more productive workplaces. **TABLE** presents this guide that is classified to relate each biophilic pattern to the theories mentioned earlier and to the health outcomes suggested by Terrapin Bright Green. Then, the suitable architectural strategy is related to each pattern in terms of workplace design based on the analyzed examples.

Biophilic strategies to be applied in the workplace can be classified into elements related to interior design concerning the spatial features, finishings, and furnishings, elements related to building design including fenestrations and building's form and outer skin and to outdoor spaces design as an integral part of the workplace design. All proposed design elements aim to foster employees' contact with nature.

TABLE 1.Key aspects of biophilic patterns applied in the workplace

Biophilic Strategies for Workplace Design		Outdoor Spaces Design	Building Design	Indoor Design
		<ul style="list-style-type: none"> - Roof terrace and outdoor gardens that foster visual connection with nature 	<ul style="list-style-type: none"> - Full height windows that access natural views - Depicting natural sceneries 	<ul style="list-style-type: none"> - Indoor plants and green walls as a part of the workplace interior design
Health Benefits[3]	3	*	*	*
	2	*	*	*
	1	*	*	*
Related Theory		Attention Restoration Theory and Stress Reduction Theory		
Biophilic Pattern	Visual connection with nature [P1]	Non-Visual connection with nature [P2]	Non-Rhythmic sensory stimuli [P3]	
	Nature in the Space			

<p>- Access to rooftop and balconies to provide outdoor prospect conditions</p>	<p>- Outdoor sheltered and private spaces as a refuge for employees</p>	<p>-</p>	<p>- Access to rooftop and balconies that increase the feelings of risk</p>
<p>Natural Analogues</p>			
<p>Biomorphic forms and patterns [P8]</p>	<p>Material connection with nature [P9]</p>	<p>Complexity and order [P10]</p>	
<p>ART</p>			<p>Savanna Hypothesis</p>
	<p>*</p>	<p>*</p>	
<p>*</p>		<p>*</p>	
<p>- Replicating forms and patterns found in nature</p>	<p>- Selection of natural materials (wood, stone, marble, etc.)</p> <p>- Color palettes inspired from nature (earthy tones, green and blue)</p>	<p>- Implementation of geometric and fractal patterns in interior design (partitions, carpet textures, modular floorings, etc.)</p>	
<p>- Fluid and organic forms in building and space design</p>	<p>-</p>	<p>- Patterned building skin</p> <p>- Exposed mechanical and structural systems</p>	

<ul style="list-style-type: none"> - Full height windows that maximize outdoor views - Open plan space layout - Elevated planes 	<ul style="list-style-type: none"> - Quiet zones for focused tasks or relaxation (swing seats, telephone pods, private nooks) 	<ul style="list-style-type: none"> - Curved walls in workplace design that give a sense of mystery 	<ul style="list-style-type: none"> - Full height windows and transparent railings provide feelings of risk from falling - Double heights - Architectural cantilevers
<ul style="list-style-type: none"> - Transparent and see-through partitions and railings to provide indoor prospect conditions 	<ul style="list-style-type: none"> - Furniture forms that allow both enclosure and privacy 	<ul style="list-style-type: none"> - See-through partitions that stimulate the user's sense of exploration - Wayfinding paths that help employees find their destination easily 	<ul style="list-style-type: none"> - Office hammocks installed over a certain height as a leisure and private space for rest
<p style="text-align: center;">*</p>			
<p style="text-align: center;">*</p>		*	*
<p style="text-align: center;">*</p>	*		
Prospect-Refuge Theory and Savanna Hypothesis			
Prospect [P11]	Refuge [P12]	Mystery [P13]	Risk/Peril [P14]
Nature of the Space			

(1) Cognitive Functionality and Performance, (2) Psychological Health, (3) Physiological Health

7. CONCLUSION

In order to improve employee's health and wellbeing, biophilic design approach is introduced in workplace design aiming to enhance mental and psychological responses of its occupants. The theories mentioned in the paper focus on the role of nature in improving human's health and wellbeing and provide a better understanding of the process of translation of biophilia hypothesis into biophilic design principles. literature review on biophilic design benefits in relation to cognitive, psychological, and physiological health is presented as well and an analytical study of several examples that better illustrate the application of biophilic patterns in workplace design is conducted.

The paper focused on studying the possible combinations of several biophilic elements into a specific building type, the workplace. The study also provided key aspects of biophilic strategies in workplace design that harness our affinity to nature and design nature back into our built environment aiming to improve the employees' experience in workplaces in relation to their cognitive, psychological, and physiological health. These design interventions can be applied in further practices as a guide for spatial design of workplaces. Further research shall study the quantity and quality of applied patterns, and biophilic design strategies in relation to environmental and weather conditions shall be studied as well in further research. Moreover, designers shall consider sensorial and social needs of building's occupants and not focus only on spatial and aesthetic aspects of space design.

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