

Research Article

Design Considerations of Biophilic Design to Improve Human Health and Well-being in Indoor Spaces

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Abstract

We spend 90% of our lives in buildings which means that our health and wellbeing are influenced significantly by the built environment. Also, there is scarceness of buildings that meet in their design the psychological needs of employees. Many researchers search about how to connect people with nature to enhance their cognitive performance, psychological and physiological health. Applying biophilic design patterns to our schools, workplaces, neighborhoods, and healthcare has profound well-being, health, and financial benefits. So the Buildings owners can collect higher rents; the workers in healthcare can see economical profits from the faster rates of recovery of patients; organizations more likely to see improved employees' productivity and in schools can see an increase in the performance of students and the rate of absenteeism decreased. This paper aims to highlight the biophilic design patterns, the nature health benefits and the design considerations needed to achieve these patterns.

Keywords: Biophilic Design, Nature, Health, Well-being

Introduction

Biophilia is the profound situated need of societies to interact with nature. It clarifies why crashing waves and crackling fires attract us; why a view to nature can improve our creativity; why heights and shadows instill fear and fascination; and why gardening and walking around parks have therapeutic effects. As a theory, Biophilia also help clarify why some buildings and urban parks are favored over others. For decade's scientists, researchers and experts have been working to describe nature's features that mostly affect our fulfillment with the built environment. However, how would we transfer from study to application by concluding a method which effectively improves health, increase productivity and well-being, and how should efficacy be measured? As new evidence appears, the relationships between nature, science and the built environment becoming clearer. This paper consists of 3 categories and 14 biophilic patterns in a way that represents the most influential nature-health relationships within the built environment. We emphasis on the patterns for which evidence has shown, at least to some degree, to impact our ability to improve and preserve a healthy life experience through link with nature.

1. Definition of Biophilic Design

Biophilia has Greek roots which mean "love of life". According to my opinion, "love of life" means love of nature, because life is made up by nature. As Human beings we are not only related to nature; but we are part of it. So, we should have a strong connection with other elements of nature in this world. If it is not available around us, we can bring it into our lives by mimicking its patterns, colors, shapes, and fractals in architectural and interior designs. The spaces in which we live should not only be functional; also, it should give spatial experience for the user which compromise a message (M. H. Mahdiniya, 2017). According to Wilson and Kellert in 1984, Biophilia is the inherent human inclination to connect with nature which continues to be critical to people's mental health, physical and wellbeing (Stephen Kellert, 2015).

Biophilic architecture is a part of an innovative architectural view, where life, nature and architectural intuition are merged to create a lively habitable edifice commensurate with the requirements, constraints and respect for both the people and environment.

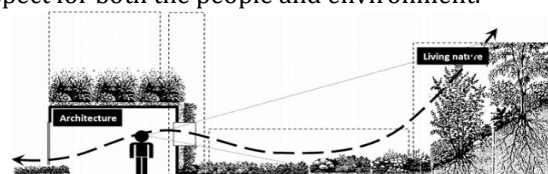


Fig.1 Architectural pattern in context of living nature upon biophilic architecture model

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2. Benefits of Biophilic Design

Despite intuitive thoughts on the benefits of affiliations with nature, an increasing amount of studies report findings that nature provides psychological and physical health benefits.

Grinde and Patil share reports of health benefits from association with nature experiences, true wilderness experiences, neighborhood parks, gardens, and natural features around residences (Grinde & Patil, 2009):

- Nature reduces stress.
- Improves attention by having a beneficial impact on mental health and dealing with deficits in attention.
- Increases longevity.

3. Nature-Health Relationships

These 14 Biophilic Design patterns concentrate on cognitive, psychological, and physiological benefits (Ankur Gutam, 2016). Throughout laboratory or field research, there are 3 basic mind-body systems – cognitive, psychological and physiological – that have been investigated and tested to various degrees to better understand how people's health and well-being affects by their environment.

3.1 Cognitive Functionality and Performance

Cognitive performance includes our memory, mental agility, and our ability to learn, think and output either creatively or logically. For example, directed attention is vital for numerous routine tasks, like reading, routine paperwork, performing calculations or analysis as well as for operating in highly stimulating environments, as when crossing busy streets. Focused attention is over time and energy intensive can lead to depleted cognitive resources and mental fatigue. Strong contacts with nature can provide chances for mental restoration, during which time our higher cognitive functions can sometimes take a break. According to result, our capacity to perform concentrated tasks is greater than those with fatigued cognitive abilities (van den Berg, 2007).

3.2 Psychological Health and Well-being

Psychological responses include our alertness, adaptability, emotion, attention, mood and focus. This contains responses to natural surroundings that impact stress and management restoration. For example, empirical researches have shown that natural environments experiences provide greater emotional restoration, with lower instances of anxiety, anger, confusion, tension, fatigue and total mood disturbance than urban environments with limited nature features.

Psychological responses may be hereditary or learned, with previous experiences, cultural constructs and social norms playing a significant role in the psychological response process (Barton, J., 2010).

3.3 Physiological Health and Well-being

Physiological responses encompass our circadian systems, aural, respiratory, musculoskeletal, and whole physical comfort. Physiological responses caused by interactions with nature include muscle relaxation, reducing blood pressure and stress hormone levels in the blood stream. Short term stress that raises stress hormone and heart levels rates, such as from encountering an unknown but complex and information-rich space, or looking over a banister to eight stories below, is suggested to be beneficial to regulating physiological health.

The physiological system needs to be periodically checked but only enough to keep the body adaptive and resilient. Physiological responses to environmental stressors should be buffered by design, so that body resources can be recovered before system damage occurs (Kandel, 2013).

4. Dimensions of Biophilic Design

In 2008 Stephen Kellert describes in his book "*Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*" the two dimensions of biophilic design: organic design and vernacular design (Kellert, 2008).

4.1 Organic Design

Concentrates on any forms or shapes that represent nature directly, indirectly or symbolically.

4.2 Place-Based or Vernacular Design

Concentrates on buildings and places themselves, and how the built environment is formed to the cultures where people live and work. It connects individuals and nature to a selected cultural and ecological setting.

5. "14 Patterns" of Biophilic Design and Health Benefits

In 2014 Browning and Ryan made effort to collect evidence for various biophilic design aspects suggested "14 patterns" and explain 3 reasons to use the term 'pattern' (Browning, W.D, 2014):

- Introducing a simple and unified biophilic design terminology;
- To avoid misunderstanding with numerous terms already used definitions such as characteristic, metric, condition, typology, attribute, etc.;
- Maximize usability by maintaining common terminology for designers and planners.

The Following Patterns in Table 1 have been explained on the basis of their:

- Design Considerations needed to achieve pattern.
- Nature Health Benefits.

Table 1 “14 Patterns” of Biophilic Design

Nature in the Space	Natural Analogue	Nature of the Space
1. Visual Connection with Nature	8. Biomorphic Forms & Patterns	11. Prospect
2. Non-Visual Connection with Nature	9. Material Connection with Nature	12. Refuge
3. Non-Rhythmic Sensory Stimuli	10. Complexity & Order	13. Mystery
4. Thermal & Airflow Variability		14. Risk/Peril
5. Presence of Water		
6. Dynamic & Diffuse Light		
7. Connection with Natural Systems		

5.1 Nature in the Space

Nature in the space address to the direct presence of nature in the built environment.

5.1.1 (P1) Visual Connection with Nature

View elements of nature, living systems and natural processes.



Fig.2 Viewing Nature from Commerzbank Headquarters

5.1.1.1 Design considerations needed to achieve Pattern

1. Give priority to the real nature instead of artificial nature or acquired aspects of nature.
2. Prioritize biodiversity more than cultivated area, whether area or quantity (Fuller *et al.*, 2007).
3. Provide opportunities to spend favorite times near the green area.
4. Design work that supports visual communication with nature by practicing life activities in at least 5:20 minutes/day (Tsunetsugu *et al.*, 2013).
5. The horizontal design of the space and the distribution of furniture within the space so as to provide a clear view of the external scenes and avoids obstructing the desired vision in all seating situations.
6. The benefits of seeing real nature can be achieved through a digital medium, which can add greater value to spaces and according to the nature of the function "such as hospital radiology units" which

cannot easily be integrated with the real environment or seeing external views.

5.1.1.2 Nature Health Benefits

- **Cognitive Performance:**
Improved attentiveness/ mental engagement.
- **Psychological Health and Well-being:**
Impacted Positively the attitude and the overall happiness.
- **Physiological Health and Well-being:**
Lowered heart rate and the blood pressure.

5.1.2 (P2) Non-Visual Connection with Nature

It can be distinguished in the form of sensory stimuli other than eyes (visual) such as hearing (auditory), touch (haptic), smell (olfactory) and taste (gustatory) that are intentionally found to refer to living systems, natural processes or nature and create a positive response.



Fig.3 A fountain and gardens in the Calat Alhambra

5.1.2.1 Design considerations needed to achieve Pattern

1. Give priority to the sounds of nature from other voices to generate physiological and psychological relief.
2. Make visual design with nature so that it can easily be accessed through one or more places, in a method that let this connection to occur for 5:20 min. at a time.
3. Merge invisible communication with other design aspects (Li *et al.*, 2012).
4. Design for visual and non-visual connections to be experienced simultaneously to maximize potential positive health responses.

5.1.2.2 Nature Health Benefits

- **Cognitive Performance:**
Impacted positively the cognitive performance.
- **Psychological Health and Well-being:**
Improvements in tranquility and mental health.
- **Physiological Health and Well-being:**

Decreased hormones of stress and systolic blood pressure.

5.1.3 Non-Rhythmic Sensory Stimuli

Random and transient links with nature can be statistically analyzed as clouds, shadows, nature sounds, and water reflections but cannot be accurately predicted



Fig.4 Kinetic facades are often a good reference to this principle

5.1.3.1 Design considerations needed to achieve Pattern

The goal of this idea is to encourage and stimulate the usage of sensory stimuli that attract attention in an unconscious way to nature and allow individual abilities to understand and interpret what they feel. This can be achieved through a design that allows for random exposure to random or unexpected movement, Odors or sounds associated with nature.

1. As a trend, the non-rhythmic sensory must be performed every 20 minutes and for about 20 seconds. And for visual stimuli, the vision must be distance at least 20 feet (Vessel, 2012).
2. In various cases, thoughts are similar to visual connection with nature or non-visual connection with nature, but the important thing here is the randomness and speed of the disappearance of this application.
3. This strategy can be incorporated with any landscape. Plants can be selected for hanging ponds in windows that will attract butterflies and bees at random.
4. The brain identifies the motion of natural objects in a better way than the movement of mechanical objects, which is perceived as a positive movement while the movement of mechanical objects is a negative movement (Mehta *et al*, 2012).
5. The peripheral zones of your field of view are the best places for positioning non-rhythmic sensory stimuli like animals, long swaying grasses and shimmering water features.

5.1.3.2 Nature Health Benefits

- *Cognitive Performance:*

Observed and quantified behavioral measures of exploration and attention.

- *Physiological Health and Well-being:*

Impacted Positively the systolic blood pressure, rate of heart, and the activity of sympathetic nervous system.

5.1.4 (P4) Thermal and Airflow Variability

It can be defined as the change in relative humidity, air temperature, air flow across the skin, temperature of surfaces that mimic natural environments. The space of this property leads to feel a sense of recovery, activity, vitality and comfort. This space gives you a sense of flexibility and control (Heerwagen, 2006).



Fig.5 Windhover Contemplative Center air flow and natural ventilation

5.1.4.1 Design considerations needed to achieve Pattern

1. Integrating thermal conditions and air flow through raw materials, daylight, industrial ventilation and architectural openings will help to distribute the fluctuations and variations within the space in environmental conditions during the time and space.
2. Maintaining low and dense vegetation between the buildings especially where high temperatures are measure.
3. Designing in a way that allows occupants of the place to control the surrounding environment temperature will increase the acceptable temperature of 2°C above or below the customary thermal comfort rate (Nicol, 2002).
4. Employing green walls and green roofs for heat gain reduction and for maintaining a fresh air flow.
5. Coordination of design plans between the early project team (e.g., architect, lighting designer and MEP engineers) will lead to the achievement of design goals.

5.1.4.2 Nature Health Benefits

- *Cognitive Performance:*

Impacted positively the concentration.

- *Psychological Health and Well-being:*

Improvement of the perception of spatial and temporal pleasure.

• *Physiological Health and Well-being:*

Positively affected well-being, comfort and the productivity.

5.1.5 (P5) Presence of Water

It is a state of improvement of the experience of being in the place during the hearing and sight or touch the water, a place that is characterized by a good presence of water leads to a sense of magic and gravity, and contributes to the sense that the place is calm and refreshing, Water does not significantly reduce our sense of interest all the time; therefore, a small water element can be sufficient. Utilizing the water flowing sound from a small fountain and our ability to touch water will maximize the health response of the multi-sensory experience (Alvarsson *et al.*, 2010).



Fig.6 Suzhou Industrial Park

5.1.5.1 Design considerations needed to achieve Pattern

1. Give priority to the Multi-Sensory experience with water to gain maximum benefit (Pheasant *et al.*, 2010).
2. Give priority to a more fluid natural movement of water than predictable movement or stagnant water (Biederman & Vessel, 2006).
3. The use of a large water element can create a sense of discomfort and affect the level of moisture and reduces the quality of sound.
4. Providing shadows above water, using surfaces with the ability to reflect the heat of the sun and reducing the surface of water exposed to the sun will reduce the water loss through evaporation and is likely to contribute to the biophysical experiment.

5.1.5.2 Nature Health Benefits

• *Cognitive Performance:*

-Improved the restoration of memory and concentration.

-Enhanced the cognition and psychological responsiveness.

• *Psychological Health and Well-being:*

Observed preferences and positive emotional responses.

• *Physiological Health and Well-being:*

The feelings of tranquility increased, reduced in stress, decreased blood pressure and the rate of the heart.

5.1.6 (P6) Dynamic and Diffuse Light

It is meant to change the intensity of light and shade over time to create conditions similar to what happens in nature, which supports the sense of drama and isolation with a sense of calm. The purpose of this application is to provide users with the ability to control light in a way that stimulates and activates the eye and attracts attention, which gives a positive psychological, physical and health response, and helps to maintain the system of the work of the biological clock (Stephen R. Keller, 2012).



Fig.7 The natural visual shift

5.1.6.1 Design considerations needed to achieve Pattern

1. Dynamic lighting conditions can help move between outdoor and indoor spaces.
2. Strongly achieved dynamic lighting conditions such as continuous motion, changing colors, sunlight that penetrates the spot directly and extreme contrast, may not be suitable for places where activities need concentration and attention (Brawley, 2009).
3. Circadian lighting is particularly convenient in places where users stay longer.
4. Indirect exposure to ambient light can be guaranteed through holes, which enhance space preference and make space appear larger. It also improves the cognitive brain function and gives positive psychological reactions.

5.1.6.2 Nature Health Benefits

• *Cognitive Performance:*

Improved perception and concentration.

• *Psychological Health and Well-being:*

Impacted Positively the emotional responsiveness.

• *Physiological Health and Well-being:*

Impacted Positively the circadian system functioning.

5.1.7 (P7) Connection with Natural Systems

Awareness of natural systems, especially seasonal and temporal changes in the health ecosystem. The place that enjoys this property stimulates the relationship with the larger and makes the person aware of the cycle of life and seasons. Experience also stimulates feeling of comfort and nostalgia (Browning, W.D, 2014).



Fig.8 Hines in Santa Ana, California

5.1.7.1 Design considerations needed to achieve Pattern

1. Integrate rainwater treatment and retention into the Landscape design so that the design responds to the state of rain.
2. The integration of responsive design techniques (e.g., use of materials that change form or expand function with exposure to solar heat gain, wind, rain/moisture, or shading), structures (e.g., steps wells), and land formations (e.g., bioswales, arroyos, dunes) will be necessary to achieve the desired level of awareness.

5.1.7.2 Nature Health Benefits

- *Psychological Health and Well-being:*
Enhanced positive health responses; Shifted perception of the environment.

5.2 Natural Analogue

Natural Analogue address to organic, non-living and indirect evocations of nature.

5.2.1 (P8) Biomorphic Forms and Patterns

Patterns and models borrowed from nature are symbolic sources of multiple systems that are still persistent and adhering to nature. The space that is applied to this style gives a sense of comfort and excitement as impressive as attractive and charming (Martin et Judith Heerwagen, 2008).



Fig.9 Twitter in Seattle

5.2.1.1 Design considerations needed to achieve Pattern

1. Avoid excessive use of wall-mounted decorative patterns and patterns that can lead to visual confusion.
2. The biomorphic attributes should be applied on two or three planes or dimensions for example (floor plane, wall, furniture, windows and soffits) for greater diversity and frequency of exposure (Salingaros, 2012).
3. Incorporating the ideas needed to achieve this idea at the beginning of design processes is considered a more efficient economic method.

5.2.1.2 Nature Health Benefits

- *Psychological Health and Well-being:*
Observed view preference.

5.2.2 (P9) Material Connection with Nature Forms and Patterns

The idea is to use raw materials and elements from nature, which through minimum operations reflect the local environment to create a distinct sense of place, where the property enjoys a sense of richness of nature, warmth, truth, and sometimes motivating the user to touch the surroundings (Browning, W.D, 2014).



Fig.10 Sustainable House, Romania uses natural materials for facades

5.2.2.1 Design considerations needed to achieve Pattern

1. The amount of raw materials and colors inspired by nature depends on the function of the place. In the same vein, the need for diversity and difference in materials and colors.
2. Raw materials are preferable to alternative materials because the user can observe the difference between them.
3. Integrating green objects that help improve environment-related design (Addington, 2012).

5.2.2.2 Nature Health Benefits

- *Cognitive Performance:*
Reduced diastolic blood pressure.
- *Psychological Health and Well-being:*
Improved comfort.

5.2.3 (P10) Complexity and Order

Complexity and system are rich sensory information that clings to the temporal sequence similar to what happens in nature. The space of this property gives a sense of attractiveness and involvement in the rich details, which brings an interesting balance between the feeling of boredom and rich in detail (Salingaros, 2012).



Fig.11 The engaging ceiling structure of the Allen Lambert Galleria and Atrium at Brookfield Place

5.2.3.1 Design considerations needed to achieve Pattern

1. Prioritize art works and selection of raw materials, architectural expressions and general horizontal projections that refer to "verification" of molecular geometry and hierarchies.
2. The third iteration of a fractal, as shown in the 1/27 Koch Snowflake Curve, is more likely to engender a positive health response than less complex designs (1/3 or 1/9).
3. Excessive use of designs based on the thought of molecular geometry with prolonged presence in a vacuum characterized by this design may give a sense of discomfort or fear.

5.2.3.2 Nature Health Benefits

- *Psychological Health and Well-being:*
Observed view preference.
- *Physiological Health and Well-being:*
impacted positively the responses of perceptual and physiological stress.

5.3 Nature of the space

Nature of the space addresses spatial configurations in nature (Wilson, E.O, 2012).

5.3.1 (P11) Prospect

Prospect is a landscape without obstacles. The space which includes a good horizontal gives a sense of comfort and openness to nature and gives a sense of security and control especially in the presence of a single user in the place or in an unusual environment for him.



Fig.13 JWT in Atlanta

5.3.1.1 Design considerations needed to achieve Pattern

1. Directing the building, windows, corridors and workstations will help improve the visual vision of the internal and external horizons.
2. Design work with or around plants and weeds as one of the methods of environmental systems, as well as about water sources.
3. Provide a focal length of >20 ft. 6 meters. The preferred distance is 100 feet (30 meters). When the space is of a suitable depth, the characteristics of this space can improve the experiment by removing visible obstacles. The height of the 42-inch enclosure will provide spatial dividers and allow occupants to see the space during the space (Herzog & Bryce 2007).
4. Laying the stairs on the borders of the building with the use of glass walls as well as internal glass walls surround the stair from the inside can be a good double vision of the horizon.
5. When the ceilings are high, the boundaries of the building or interior walls must not exceed 12 to 18 inches height, which improves visibility of the horizon (Dosen,2013).

5.3.1.2 Nature Health Benefits

- *Cognitive Performance:*
Decreased irritation, boredom, fatigue.
- *Psychological Health and Well-being:*
Improved comfort and perceived safety.
- *Physiological Health and Well-being:*
Reduced stress.

5.3.2 (P12) Refuge

A shelter is a place of refuge from environmental conditions or a place where the individual is concealed within it so that it performs a series of activities. A place that has good qualities as a shelter gives a feeling of security, seclusion and isolation for activities such as work, rest, shelter, hospitalization either individually or with a small group of people (Grahn, 2012).



Fig.14 Hubspot in Cambridge

5.3.2.1 Design considerations needed to achieve Pattern

1. Places with low ceilings are often characterized by spaces with standard roof heights that are approximately 18-24 inches below the main roof and are often carried out by borrowed ceiling or sound booths.
2. Internal and external spaces with a roof height greater than 14 feet, a radical difference in height must be achieved to reach the desired goal. Freestanding objects, plant cavities and mezzanines are positive solutions.
3. In the case of the design of a meeting building of public or multifunctional buildings, the provision of more than one shelter space can address the different needs; by making spaces of different dimensions, different lighting conditions, different degrees of privacy.
4. The lighting levels in the spaces that act as a shelter prefer to be different from the normal spaces, and the user's lighting control extends the space use as a shelter.

5.3.2.2 Nature Health Benefits

- *Cognitive Performance:*
Improved concentration, attention and perception of safety.

5.3.3 (P13) Mystery

The Mystery pattern is defined as the promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment. A space with a good Mystery condition has a palpable sense of anticipation, or of being teased, offering the senses a kind of denial and reward that compels one to further investigate the space. A Mystery condition does not feel like a “don’t-open-that-door horror movie moment” (i.e., surprising, unpleasant, dangerous). Rather, it slowly reveals a new condition, feature, or information (Ikemi, 2005).

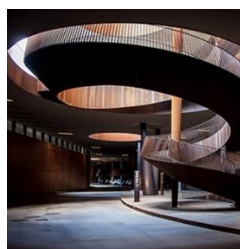


Fig.15 Avoiding horror movie

5.3.3.1 Design considerations needed to achieve Pattern

1. Curved characters and corners are more influential than sharp angles to draw the attention of people and also fascinate them more.
2. "Artificial" play shadows improved the design experience.
3. The use of design methods that provide dark shades or shallow depth to achieve a sense of surprise or fear.
4. The speed at which the user moves within the space will affect the size of the openings and the design elements. The faster it means the larger the size.
5. Add naturally ambiguous conditions, such as: reducing the maintenance of gardens with winding corridors so that the shape changes over time.

5.3.3.2 Nature Health Benefits

- *Psychological Health and Well-being:*
Induced strong pleasure response.

5.3.4 (P14) Risk/Peril

It is an unspecified threat combined with a reliable protection. A place that enjoys this status gives a feeling of excitement and joy, with an implied threat, and perhaps a little discomfort that the individual feels at risk but with pleasure (Minke.G, 2001).



Fig.16 The Levitated Mass at Los Angeles County Museum of Art

5.3.4.1 Design considerations needed to achieve Pattern

1. Design is usually deliberate and thoughtful, so it is not suitable for all users or for all places.
2. Design plans based on space conditions will be easier to implement.
3. The safety element should protect the user from harm while maintaining a sense of the seriousness of the experience (Deriu, D., 2017).

5.3.4.2 Nature Health Benefits

- *Psychological Health and Well-being:*
Resulted in strong dopamine or pleasure responses.

5. Findings

It was found after searches that the importance of implementing biophilic patterns in spaces are:

- In offices, the productivity can be improved by (8%), wellbeing rates up by (13%), increases in creativity, with reduced presenteeism and absenteeism.
- In hospitality, visitors ready to pay 23% extra for rooms with natural view.
- In education spaces, rates of learning increased by 20-25%, improved concentration levels, attendance and test results.
- In Healthcare Spaces, the recovery times after surgery reduced by 8.5% and the usage of pain medication reduced by 22%.
- At Home, it becomes more calming & restorative, with 7-8 % less crime attributed to areas with access to nature and can command an increase of 4-5% in property price.

Conclusions

The aim of the research was reaching to the design considerations of biophilic design and its impact on human health. Therefore, they were concluded within each of the 14 patterns explanation. Based on that, the objective of the research was reached.

Factors such as socio-economic status, genetics, and level of exercise, each factor affect the baselines for measuring stress and mitigating it. So, it's needed more studies to inherently quantify some biophilic aspects.

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