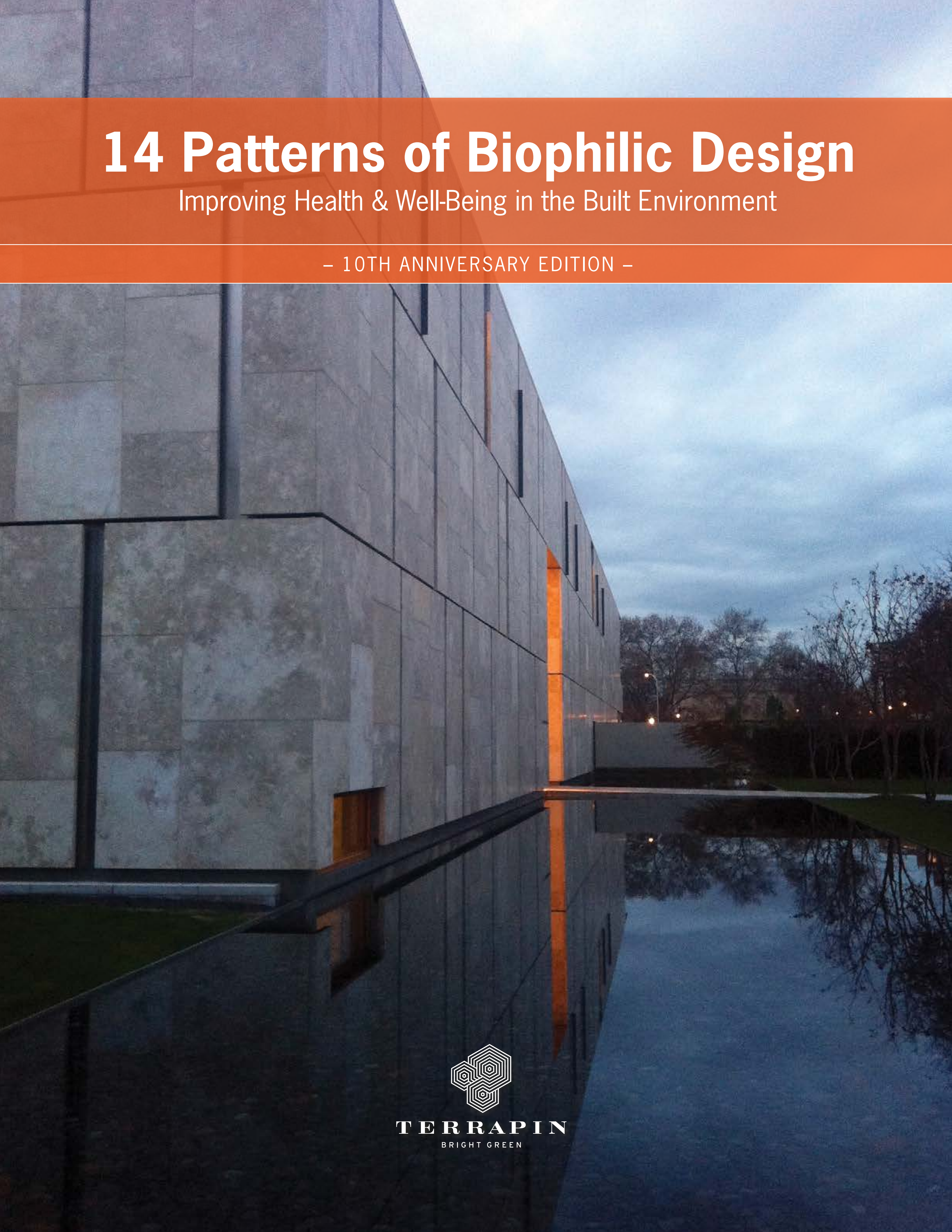
14 Patterns of Biophilic Design

Improving Health & Well-Being in the Built Environment

– 10TH ANNIVERSARY EDITION –



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“…the enjoyment of scenery employs the mind without fatigue and yet exercises it, tranquilizes it and yet enlivens it;

and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system.”

Frederick Law Olmsted, 1865
Introduction to Yosemite and the Mariposa Grove: A Preliminary Report

Revised April 2026

Front cover image: Presence of Water, Material Connection with Nature, Mystery, and Risk/Peril. The Barnes Foundation in Philadelphia, PA, designed by Williams & Tsein © Bill Browning.

Back cover image: Dynamic & Diffuse Light, Visual and Material Connections with Nature, Prospect, and Awe. PDX Airport Terminal in 2024 designed by ZGF Architects, in Portland, Oregon, USA © Catie Ryan.

Acknowledgements

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We also thank our international partners for extending our reach by making the first edition available in other languages, each of which can be freely accessed from Terrapin's webpage for "14 Patterns of Biophilic Design".

Dutch	Biophilix®
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Spanish	National University of Costa Rica

14+ Patterns of Biophilic Design

Improving Health and Well-Being in the Built Environment

Overview

Biophilic design can reduce stress, enhance creativity and clarity of thought, improve our well-being and expedite healing; as the world population continues to urbanize, these qualities are ever more important. Theorists, research scientists, and design practitioners have been working for decades to define aspects of nature that most impact our satisfaction with the built environment. **"14 Patterns of Biophilic Design"** articulates the relationships between nature, human biology and the design of the built environment so that we may experience the human benefits of biophilia in our design applications. Though not every pattern has been updated with the latest research, this tenth anniversary edition of the 2014 publication clarifies and builds on knowledge of past research and adds a fifteenth pattern, Awe, with its unique spatial conditions and health outcomes.

This publication is organized into three main sections. **Biophilia in Context** looks at the evolution of biophilic design in architecture and planning and presents a framework for relating the human biological science and nature with the design process. **Design Considerations** explores a sampling of factors (e.g., scale, climate, user demographics) that may influence biophilic design decisions to bring greater clarity to why some interventions are replicable and why others may not be. **The Patterns** lays out a series of perspectives for understanding design opportunities, including the roots of the science behind each pattern, and the metrics, strategies and considerations for how to use each pattern. This publication moves from research on biophilic responses to design application as a way to effectively communicate ideas and enhance health and well-being for individuals and society through design.

Contents

> “A new discipline needs to abstract its patterns as they appear. It is building its own foundation and logical skeleton, upon which future growth can be supported. **Knowing its basic patterns early on will speed up the language’s development, and guide it in the right direction.”**
>
> Nikos A. Salingaros, 2000
> “The Structure of Pattern Languages”

Introduction

Biophilic design can reduce stress, improve cognitive function and creativity, improve our well-being and expedite healing; as the world population continues to urbanize, these qualities are ever more important. The escalating biodiversity and public health crises, climate emergency declarations, and remote working phenomenon further emphasize this imperative to find creative solutions for how we build for a better future. Given how quickly an experience of nature can elicit a restorative response —in as little as 40 seconds—and the fact that U.S. businesses alone squander billions of dollars each year on lost productivity due to stress-related illnesses, biophilic design becomes an essential tool for providing people with places and spaces in which to live, work and play that lower stress, enable greater overall health and well-being and, ideally, engender environmental stewardship.

Biophilia is humankind’s innate biological connection with nature. It helps explain why crackling fires and crashing waves captivate us; why a garden view can enhance our creativity; why shadows and heights instill fascination and fear; and why animal companionship and strolling through a park have restorative, healing effects. Biophilia may also help explain why some urban parks and buildings are preferred over others. For decades, research scientists and design practitioners have been working to define aspects of nature that most impact our satisfaction with the built environment. But how do we move from research to application in a manner that effectively enhances health and well-being, and how should efficacy be measured or critiqued?

Building upon “The Economics of Biophilia” (Terrapin Bright Green, 2012; 2023), the intent of this publication is to articulate the relationships between nature, science, and the built environment so that we may experience the human benefits of biophilia in our design applications. The publication presents a framework for biophilic design that is reflective of the nature-health relationships most important in the built environment—those that are known to enhance our lives through a connection with nature.

Ample research supports measurable, positive impacts of biophilic design on health, strengthening the empirical evidence for the human–nature connection and raising its priority level within both design research and design practice; however, guidance for implementation is still limited. This publication is intended to help close the gap between current research and implementation. The intended audiences of this publication are interior designers, architects, landscape architects, urban designers, planners, health professionals, employers and developers, as well as anyone wanting to better understand the patterns of biophilia.

This publication puts biophilic design in context with architectural history, health sciences and current architectural practices, and touches on implementation

Moon Gate at Lan Su Chinese Garden
in Portland, OR © Bill Browning.

considerations, then presents biophilic design patterns. These patterns have been developed through extensive interdisciplinary research and are supported by empirical evidence and the work of Christopher Alexander, Judith Heerwagen, Rachel and Stephen Kaplan, Stephen Kellert, Roger Ulrich, and many others. Several hundred publications on biophilic responses have been mined and analyzed to reveal distinct patterns useful to designers of the built environment. Biophilic design patterns have a wide range of applications for both interior and exterior environments, and are meant to be flexible and adaptive, allowing for project-appropriate implementation.

Finally, this publication discusses these patterns in a general sense for the purpose of addressing universal issues of human health and well-being (e.g., stress, visual acuity, hormone balance, creativity) within the built environment, rather than program-based or sector-specific space types (e.g., health care facility waiting rooms, elementary school classrooms, or storefront pedestrian promenades). As such, the focus is on patterns in nature known, suggested or theorized to mitigate common stressors or enhance desirable qualities that can be applied across various sectors and scales.

We hope this publication continues to serve as a foundation for thinking more critically about the human connection with nature and how biophilic design patterns can be used as a tool for improving health and well-being in the built environment.

14+ Patterns of Biophilic Design

Nature in the Space

1. Visual Connection with Nature
2. Non-Visual Connection with Nature
3. Non-Rhythmic Sensory Stimuli
4. Thermal & Airflow Variability
5. Presence of Water
6. Dynamic & Diffuse Light
7. Connection with Natural Systems

Natural Analogues

8. Biomorphic Forms & Patterns
9. Material Connection with Nature
10. Complexity & Order

Nature of the Space

11. Prospect
12. Refuge
13. Mystery
14. Risk/Peril
15. Awe

Biophilia in Context

> **"In every walk with nature one receives far more than one seeks."**
>
> John Muir, 19 July 1877

Rediscovering the Intuitively Obvious

Nature themes can be found in the earliest human structures: Stylized animals characteristic of the Neolithic Göbekli Tepe; the Egyptian sphinx, or the acanthus leaves adorning Greek temples and their Vitruvian origin story; from the primitive hut to the delicate, leafy filigrees of Rococo design. Representations of animals and plants have long been used for decorative and symbolic ornamentation. Beyond representation, cultures around the world have long brought nature into homes and public spaces. Classic examples include the garden courtyards of the Alhambra in Spain, porcelain fish bowls in ancient China, the aviary in Teotihuacan (ancient Mexico City), bonsai in Japanese homes, papyrus ponds in the homes of Egyptian nobles, the cottage garden in medieval Germany, or the elusive hanging gardens of Babylon.

The consistency of natural themes in historic structures and places suggests that biophilic design is not a new phenomenon; rather, as a field of applied science, it is the codification of history, human intuition and neural sciences showing that connections with nature are vital to maintaining a healthful and vibrant existence as an urban species.

Prior to and even after the Industrial Revolution, the majority of humans lived an agrarian existence, living much of their lives among nature. American landscape architect Frederick Law Olmsted argued in 1865, that "…the enjoyment of scenery employs the mind without fatigue and yet exercises it, tranquilizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system" (Olmsted, 1993). As urban populations grew in the 19th Century, reformers became increasingly concerned with health and sanitation issues such as fire hazards and dysentery. The creation of large public parks became a campaign to improve the health and reduce the stress of urban living.

Artists and designers of the Victorian era, such as influential English painter and art critic, John Ruskin, pushed back against what they saw as the dehumanizing experience of industrial cities. They argued for objects and buildings that reflected the hand of the craftsman and drew from nature for inspiration. In the design of the Science Museum at Oxford, Ruskin is said to have told the masons to use the surrounding countryside for inspiration, resulting in the hand-carved flowers and plants that adorn the museum (Kellert & Finnegan, 2011).

Western attitudes toward nature were shifting in the mid-19th Century; natural landscapes became valid art subjects, as seen in the Hudson River School and the Barbizon School in France. Going to the mountains or seashore for recreation was becoming a growing trend; Winter gardens and conservatories become requisites of wealthy homes in Europe and the United States. Henry David Thoreau built a cabin by Walden Pond in

Concord, Massachusetts from which he wrote treatises on a simpler life, connected to nature, which still resonate in the American consciousness. In hospital design, sunlight and a view to nature was believed to be important, as can be seen at St. Elizabeth's in Washington, D.C. Designed in the 1850s to the concepts of Dr. Thomas Kirkbride, who "…believed that the beautiful setting…restored patients to a more natural balance of the senses" (Sternberg, 2009).

Inspiration from nature was in full view in the Art Nouveau designs of the late 19th Century. Architect Victor Horta's exuberant plant tendrils lacing through buildings in Belgium, the lush flowers that are Louis Comfort Tiffany lamps, and the explicitly biomorphic forms of Antonio Gaudí's buildings all remain strong examples. In Chicago, Louis Sullivan created elaborate ornamentation with leaves and cornices that represent tree branches. Sullivan's protégé Frank Lloyd Wright was among the group that launched The Prairie School.

Wright abstracted prairie flowers and plants for his art glass windows and ornamentation. Like many in the Craftsman movement, Wright used the grain of wood and texture of brick and stone as a decorative element. Wright also opened up interiors to flow through houses in ways that had not been done before, creating prospect views balanced with intimate refuges. His later designs sometimes include exhilarating spaces, like the balcony cantilevering out over the waterfall at Fallingwater.

Post-war European Modernists stripped much ornamentation from their buildings, but, like Wright, used wood grain and veined stone as decorative elements, and were equally concerned with exploring the relationship of interior to exterior. Ludwig Mies van der Rohe's Barcelona Pavilion (built 1929) pushed that concept with the play between volumes and glass. Later in Rohe's career, the Farnsworth House (built 1951) defined interior and exterior much more literally, segregating the elements (wind, rain, solar heat) from the visual connection with nature.

Le Corbusier's Cité Radiant (unbuilt 1924) may have resulted in disastrous urban designs, but by putting towers in a park surrounded by grass and trees, he was trying to provide city dwellers with a connection to nature. As the International Style took root, glass building construction spead rapidly; the buildings, and particularly commercial building interiors, disconnected people from nature.

The term 'biophilia' was first coined by social psychologist Erich Fromm (*The Heart of Man*, 1964) and later popularized by biologist Edward Wilson (*Biophilia*, 1984). The sundry denotations—which have evolved from within the fields of biology and psychology, and been adapted to the fields of neuroscience, endocrinology, architecture and beyond—all relate back to the desire for a (re)connection with nature and natural systems. That we should be genetically predisposed to prefer and benefit from certain types of nature experiences and natural scenery, specifically the savanna, was posited by Gordon Orians and Judith Heerwagen (*Savanna Hypothesis*,

Top: Animal stone carvings at the ancient Göbekli Tepe. Image © Teomancimit.

Middle: Victor Horta's art nouveau plant tendril designs in Hotel Tassel, Belgium. Image © Eloise Moorhead.

Bottom: The play of volumes and glass in Mies Van Der Rohe's Farnsworth House. Image © Devyn Caldwell/Flickr.

A Louis Comfort Tiffany Lamp with flower pattern design. Image © Eric Hunt/Flickr.

1986), and could theoretically be a contributing motivation for moving to the suburbs, with the suburban lawn being a savanna for everyone.

With the emergence of the green building movement in the early 1990s, linkages were made between improved environmental quality and worker productivity (Browning & Romm, 1994). While the financial gains due to productivity improvements were considered significant, productivity was eventually identified as a placeholder for health and well-being, which evidently have even broader impact. The healing power of a connection with nature was established by Roger Ulrich's landmark study comparing recovery rates of patients with and without a view to nature (Ulrich, 1984). An experiment at a new Herman Miller manufacturing facility, designed by William McDonough + Partners in the 1990s, was one of the first to specifically frame the mechanism for gains in productivity to connecting building occupants to nature—now familiarly known as biophilic design (Heerwagen & Hase, 2001).

The translation of biophilia as a hypothesis into design of the built environment was the topic of a 2004 conference and subsequent book on biophilic design (Kellert, Heerwagen & Mador, 2008) in which Stephen Kellert identified more than 70 different mechanisms for engendering a biophilic experience, and contributing authors William Browning and Jenifer Seal-Cramer outlined three classifications of user experience: Nature in the Space, Natural Analogues, and Nature of the Space.

Recent decades have seen a steady growth in research and practice around the intersections of neuroscience and architecture. A series of popular texts were foundational in bringing the conversation mainstream, helping the public grapple with modern society's dependency on technology and persistent disconnect with nature.

- *Last Child in the Woods* (Louv, 2008)
- *Healing Spaces* (Sternberg, 2009)
- *The Shape of Green* (Hosey, 2012)
- *Your Brain on Nature* (Selhub & Logan, 2012)
- The Economics of Biophilia, 1st ed. (Browning et al., 2012)
- 14 Patterns of Biophilic Design (Browning, Ryan & Clancy, 2014)

Literature has since expanded with notable publications that have helped further the narrative, moving beyond theory to showcase exceptional projects, and a deeper look at the science and societal benefits.

- *Handbook of Biophilic City Planning & Design* (Beatley, 2017)
- *Creating Biophilic Buildings* (Sturgeon, 2017)
- *Nature by Design* (Kellert, 2018)
- *The Nature Fix* (Williams, 2018)
- *Nature Inside, a Biophilic Design Guide* (Browning & Ryan, 2020)
- The Economics of Biophilia, 2nd ed. (Ryan, Browning & Walker, 2023)

Green building standards have incorporated biophilic design, predominantly for its contribution to indoor environmental quality, mental health, and connection to place. Biophilic design is now championed as a complementary strategy for addressing workplace stress, student performance, patient recovery, community cohesiveness and other familiar challenges to health and overall well-being.

Defining Nature

Views of what constitutes natural, nature, wild, or beautiful greatly vary. While we have no intention of formalizing an explicit definition, some articulation of what we mean by 'nature' will help give context to practitioners of biophilic design. Simply put, there are two inverse connotations of nature. One is that nature is only that which can be classified as a living organism or system unaffected by anthropogenic impacts—a narrow perspective of nature (reminiscent of hands-off environmental preservation) that ultimately no longer exists because nearly everything on Earth has been and will continue to be impacted at least indirectly by humans. Additionally, this idea of nature essentially excludes everything from the sun and moon, your pet fish Nemo, home gardens and urban parks, to humans and the billions of living organisms that make up the biome of the human gut.

At the other end of the spectrum, some argue that everything, including all that humans design and make, is natural and a part of nature because they are each extensions of our phenotype. This perspective inevitably includes everything from paperback books and plastic chairs to chlorinated swimming pools and asphalt roadways.

As a middle ground, for the purpose of understanding the context of Biophilic Design, we are defining nature biocentrically as living organisms and abiotic components of an ecosystem—inclusive of everything from the sun and moon, the atmosphere and seasonal arroyos to managed forests and urban raingardens, to you and Nemo's fishbowl habitat.

Nature and Sustainable Design

For added clarity, we are making the distinction that, in the context of health and well-being in the built environment, most nature in modern society is designed, whether deliberately (for function or aesthetic), haphazardly (for navigability or access to resources), or passively (through neglect or hands-off preservation); thus, we refer back to humankind's proclivity for savanna landscapes. Humans create savanna analogues all the time. As designed ecosystems, some, such as the high canopy forests with floral undergrowth maintained by the annual burning practices of the Ojibwe people of North America, are biodiverse, vibrant and ecologically healthy. Others, such as suburban lawns and golf courses, are chemical dependent monocultures; while beautiful by some standards, they are not biodiverse, ecologically healthy or resilient.

"This is what I prayed for," wrote the Roman poet Horace.

"A piece of land – not so very big, with a garden and, near the house, a spring that never fails, and a bit of wood to round it off."

Those words were set down more than 2000 years ago, around 30 B.C. It is easy to understand the emotion prompting them; we still recognize what Horace meant by a rural garden, a place to take refuge, as he did, from the irritations of city life.

Then And Now: Reflections On The Millennium; The Allure of Place in a Mobile World
December 15, 1999
New York Times Editorial
(anonymous)

The key distinction is that some designed environments are well-adapted (supporting long-term life) and some are not. So while golf courses and suburban lawns may be a savanna analogue, in many cases they require intense inputs of water and fertilizer and are thus unsustainable design practices.

Nature-Design Relationships

Browning and Seal-Cramer's (2008) categorization organizes experiences of nature into three categories—Nature in the Space, Natural Analogues, and Nature of the Space—to provide a framework for understanding and enabling thoughtful incorporation of a rich diversity of strategies for the built environment.

Nature in the Space

Nature in the Space pertains to the direct, physical and ephemeral presence of nature in a space or place. This includes plant life, water and animals, as well as breezes, sounds, scents, and other perceptions such as the passage of time. Common examples include sky views, quality daylight, potted plants, flowerbeds, bird feeders, butterfly gardens, water features, fountains, aquariums, courtyard gardens and green walls or vegetated roofs. The strongest Nature in the Space experiences are achieved through the creation of meaningful, direct connections with these natural elements, particularly through diversity, movement and multi-sensory interactions.

Nature in the Space encompasses seven biophilic design patterns:

1. **Visual Connection with Nature.** A view to elements of nature, living systems and natural processes.
2. **Non-Visual Connection with Nature.** Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.
3. **Non-Rhythmic Sensory Stimuli.** Stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely.
4. **Thermal & Airflow Variability.** Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.
5. **Presence of Water.** A condition that enhances the experience of a place through seeing, hearing or touching water.
6. **Dynamic & Diffuse Light.** Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature.
7. **Connection with Natural Systems.** Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.

Natural Analogues

Natural Analogues pertains to organic, non-living and indirect evocations of nature. Objects, materials, colors, shapes, sequences and fractal patterns found in nature, manifest as artwork, ornamentation, furniture, décor, and textiles in the built environment. Mimicry of shells and leaves, furniture with organic shapes, and natural materials that have been processed or extensively altered (e.g., wood planks, granite tabletops), each provide an indirect connection with nature: while they are real, they are only analogous of the items in their 'natural' state. The strongest Natural Analogue experiences are achieved by providing information richness in an organized and sometimes evolving manner.

Natural Analogues encompasses three patterns of biophilic design:

8. **Biomorphic Forms & Patterns.** Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature.
9. **Material Connection with Nature.** Materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place.
10. **Complexity & Order.** Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.

Nature of the Space

Nature of the Space pertains to spatial configurations in nature. This includes our innate and learned desire to be able to see beyond our immediate surroundings, our fascination with the slightly dangerous or unknown; obscured views and revelatory moments; and sometimes even phobia-inducing properties when they include a trusted element of safety. The strongest Nature of the Space experiences are achieved through the creation of deliberate and engaging spatial configurations.

Nature of the Space encompasses five biophilic design patterns:

11. **Prospect.** An unimpeded view over a distance, for surveillance and planning.
12. **Refuge.** A place for withdrawal from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.
13. **Mystery.** The promise of more information, achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.
14. **Risk/Peril.** An identifiable threat coupled with a reliable safeguard.
15. **Awe**. Stimuli that defy an existing frame of reference and lead to a change in perception.

Top: Meandering path with distant views through savana-like forest to sky and sea scape. Image by by Sven Lachmann from Pixabay.

Middle: Façade renovation of Suites Avenue Aparthotel by Toyo Ito, Barcelona, Spain, is biomorphic in form, while enhancing the Dynamic & Diffuse light and shadows filtering to the interior space. Image © Aslai/Flickr.

Bottom: Stepping stones at the Fort Worth Water Garden, Fort Worth, Texas. Image © JayRaz/Flickr.

Table 1. Biophilic Design Patterns & Biological Responses

Table 1 illustrates the functions of each of the 15 patterns in supporting (a) physiological stress reduction, (b) cognitive function and performance, and (c) emotion, mood and preference in the human body. Patterns that are supported by more rigorous empirical data are marked with up to three asterisks (***), indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, while no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern.

		Biophilic Pattern	Physiological & Stress	Cognitive Performance	Emotion, Mood & Preference
NATURE IN THE SPACE	***	**Visual Connection with Nature**	• Lowered systolic blood pressure and heart rate • Increased parasympathetic activity • Faster stress recovery • Increased physical activity • More effective physiological relaxation	• Improved mental engagement, attentiveness and attention	• Positively impacted attitude and overall happiness • Reduced future discounting • Heightened appreciation for nature • Decreased rumination • Greater motivation • More effective psychological relaxation
NATURE IN THE SPACE	***	**Non-Visual Connection with Nature**	• Reduced systolic blood pressure and stress hormones • Improved immune function • Improved cardio-respiratory response • Maintained joint flexibility • Relaxation through a change in cerebral blood flow rates	• Positively impacted cognitive performance • Improved creativity • Reduced cognitive fatigue • Reduced self-reported fatigue	• Perceived improvements in mental health, tranquility, and pain management • Improved preference • Olfactory-induced energy moderation • Haptics-induced improvement in environmental stewardship among children
NATURE IN THE SPACE	**	**Non-Rhythmic Sensory Stimuli**	• Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity		• Increase dwell time and observed behavioral measures of attention and exploration
NATURE IN THE SPACE	**	**Thermal & Airflow Variability**	• Positively impacted comfort, well-being and productivity • Fewer self-reported Sick Building Syndrome cases	• Improved task performance	• Improved perception of temporal and spatial pleasure (alliesthesia)
NATURE IN THE SPACE	**	**Presence of Water**	• Reduced stress • Increased feelings of tranquility • Lowered heart rate and blood pressure	• Positively impacted cognitive performance and creativity	• Improved preferences and positive emotional responses
NATURE IN THE SPACE	***	**Dynamic & Diffuse Light**	• Positively impacted circadian system functioning • Increased visual comfort	• Improvements to cognitive and behavioral performance	• Positively impacted attitude and overall happiness
NATURE IN THE SPACE		**Connection with Natural Systems**	• Enhanced positive health responses; Shifted perception of environment		• Enhanced positive health responses; Shifted perception of environment
NATURAL ANALOGUES	*	**Biomorphic Forms & Patterns**	• Improved stress recovery	• Improved learning outcomes	• Increased view preference
NATURAL ANALOGUES	**	**Material Connection with Nature**	• Decreased diastolic blood pressure • Improved comfort • Reduced plasma cortisol level • Increased parasympathetic (rest) activity • Increased heart rate variability • Self-reported calming effect		• Improved material preference
NATURAL ANALOGUES	**	**Complexity & Order**	• Positively impacted perceptual and physiological stress responses	• Brainwave response indicative of relaxation • Improved environmental navigation • Improved learning outcomes	• Subjective improvement to mood and preference
NATURE OF THE SPACE	***	**Prospect**	• Reduced stress • Improved comfort and perceived safety		• Improved visual preference • Reduced boredom, irritation, fatigue
NATURE OF THE SPACE	**	**Refuge**	• Restoration • Improved perception of safety		• Improved visual preference • Social-emotional learning
NATURE OF THE SPACE	*	**Mystery**			• Improved visual preference • Induced pleasure response
NATURE OF THE SPACE	*	**Risk/Peril**			• Induced dopamine/pleasure response
NATURE OF THE SPACE	**	**Awe**	• Reduced stress related symptoms • Increased parasympathetic activity • Lower levels of inflammation	• Improved capacity for attention • Reduced self-referential processing	• Increased pro-social behavior • Positively impacted attitude and overall happiness

See Appendix 2 on pages 64–65 for the expanded version of this table complete with research citations.

Periodically throughout this publication, these patterns will be referred to in shorthand by their number 1 to 15. For instance, Presence of Water is the fifth pattern and will appear as [Pattern #5, or P5], while Prospect, the eleventh pattern, will appear as [Pattern #11, or P11].

Nature-Health Relationships

Much of the evidence for biophilia can be linked to research in one or more of three overarching mind-body systems – cognitive, psychological and physiological – that have been explored and verified to varying degrees, in laboratory or field studies, to help explain how people's health and well-being are impacted by their environment. To familiarize the reader with these nature-health relationships, these mind-body systems are discussed here in the briefest sense, and are supported with a table of familiar hormones and neurotransmitters, environmental stressors, and biophilic design strategies. See Table 1 for relationships between biophilic design patterns and mind-body impacts.

Cognitive Functionality and Performance

Cognitive functioning encompasses our mental agility and memory, and our ability to think, learn and output either logically or creatively. For instance, directed attention is required for many repetitive tasks, such as routine paperwork, reading and performing calculations or analysis, as well as for operating in highly stimulating environments, as when crossing busy streets. Directed attention is energy intensive and, over time, can result in mental fatigue and depleted cognitive resources (e.g., Kellert et al., 2008; van den Berg et al., 2007).

Strong or routine connections with nature can provide opportunities for mental restoration, during which time our higher cognitive functions are able to take a break. This quieting of the prefrontal cortex leads to attention restoration, or cognitive fatigue recovery (Kaplan, 1995), and viewing nature for as little as 40 seconds can trigger this response (e.g., Lee et al., 2015). As a result, our capacity for performing focused tasks is greater than someone with fatigued cognitive resources.

Mental Health and Well-being

Psychological responses encompass our adaptability, alertness, attention, concentration, and emotion and mood. This includes responses to nature that impact restoration and stress management. For instance, empirical studies have reported that experiences of natural environments provide greater emotional restoration, with lower instances of tension, anxiety, anger, fatigue, confusion and total mood disturbance than urban environments with limited characteristics of nature (e.g., Alcock et al., 2014; Barton & Pretty, 2010; Hartig et al., 2003; Hartig et al., 1991).

Stress, Well-being & Mental Health

Mental health is a multi-faceted, complex problem. Contemporary perspectives have concluded that whilst an individual health issue, it requires a systems-thinking approach to public health to tackle. Part of this integrated approach must include the design of our built environment and how it influences our mental health and wellbeing.

For an overview on "well-being" and mental health – definitions, metrics, research, management tactics – see resources at The Centers for Disease Control and Prevention (CDC).

For a background on stress and the role of nature, see "Introduction to Restorative Urbanism" in *Restorative Cities, Urban Design for Mental Health and Wellbeing* (Roe & McCay, 2021, p1–16). See also "Mazes and Labyrinths" in *Healing Spaces* (Sternberg, 2009, p95–124).

For an extensive non-technical discussion on the science of nature's influence on health, happiness and vitality, see The *Nature Fix* (Williams, 2017).

For a technical introduction to the hormones and neurotransmitters that govern our mind-body systems, see *Principles of Neural Science, Sixth Edition* (Kandel et al., 2021).

Psychological responses can be learned or hereditary, with past experiences, cultural constructs and social norms playing a significant role in the psychological response mechanism.

Physiological Health and Well-being

Physiological responses encompass our aural, musculoskeletal, respiratory, circadian systems and overall physical comfort. Physiological responses triggered by connections with nature include relaxation of muscles, as well as lowering of diastolic blood pressure and stress hormone (i.e., cortisol) levels in the blood stream (e.g., Park et al., 2009). Short term stress that increases heart rate and stress hormone levels, such as from encountering an unknown but complex and information-rich space, or looking over a banister to 8 stories below, are suggested to be beneficial to regulating physiological health (Kandel et al., 2013).

The physiological system needs to be tested regularly, but only enough for the body to remain resilient and adaptive. Physiological responses to environmental stressors can be buffered through design, allowing for the restoration of bodily resources before system damage occurs (Steg, 2007).

Design Consider-ations

What is Good Biophilic Design?

Biophilic design is the designing for people as a biological organism, respecting the mind-body systems as indicators of health and well-being in the context of what is locally appropriate and responsive. Good biophilic design draws from influential perspectives – health conditions, socio-cultural norms and expectations, past experiences, frequency and duration of the user experience, the many speeds at which it may be encountered, and user perception and processing of the experience – to create spaces that are inspirational, restorative, and healthy, as well as integrative with the functionality of the place and the (urban) ecosystem to which it is applied. Above all, **biophilic design must nurture a love of place**.

Planning for Implementation

Densifying urban environments, coupled with rising land values, elevate the importance of biophilic design across a spatial continuum from new and existing buildings to parks and streetscapes, and to campus, urban and regional planning. Each context has the capacity to support myriad opportunities for integrative biophilic design and mainstreaming healthy building practices for people and society. Discussed here in brief are some key perspectives that may help focus the planning and design process.

Identifying desired responses and outcomes

Understanding a project's design intent is vital to a designer—asking, What are the health or performance priorities of the intended users? To identify design strategies and interventions that restore or enhance well-being, project teams should understand the health baseline or performance needs of the target population. One approach is to ask 'What is the most biophilic space we can conceivably design?' Another is to ask 'How can biophilic design improve performance metrics already used by the client?' (e.g., company executives, school board, city officials), such as absenteeism, perceived comfort, health care claims, asthma, ticket sales, or test scores.

As many biological responses to design occur together (e.g., reduced physiological stress and improved overall mood), and there are countless combinations of design patterns and interventions, understanding health related priorities will help focus design decisions. Health outcomes associated with biophilic spaces are of interest to building and portfolio managers and human resources administrators because they inform long–term design and measurement best practices, and to planners, policy makers and others because they inform public health policy and urban planning.

> **“There is rarely a solution that is universal. Rather, the ‘correct’ solution, in our view, is one that is locally appropriate and responsive to the situation at hand.”**
>
> Rachel Kaplan, Stephen Kaplan & Robert L. Ryan, 1998
> *With People in Mind*

Design strategies and interventions

Biophilic design patterns present an opportunity to create flexible and replicable strategies for enhancing the user experience under a range of circumstances. Just as lighting design for a classroom will differ from a spa or hotel lobby, biophilic design interventions are based on the needs of a specific population in a particular space.

For example, a project team may embrace the Visual Connection with Nature pattern to enhance cognitive performance among stationary desk workers for a series of interior fit-outs for a portfolio of offices. Strategies may be focused on improving view access and introducing vegetation into the workplace. Interventions may include the installation of a green wall, desks oriented to maximize views to the green wall and to the outdoors, and the establishment of an employee stipend for desk plants. While the influencing factors (e.g., local ecology and climate, urban context, existing building conditions, population, total project scope), and extent to which each of these interventions is implemented may differ for each of the offices in the portfolio, strategies, technologies, and policies often remain consistent.

A project team charged with reducing stress among emergency room nurses at the local hospital may intervene by replacing the abstract art with landscape paintings in the staffroom and installing a small garden and seating area in the adjacent interior courtyard. While this project also uses the Visual Connection with Nature pattern, the selected interventions specifically target stress reduction for emergency room nurses based on a shared space they utilize routinely.

Pattern layering

Patterns in combination tend to increase the likelihood of health benefits of a space. Incorporating a diverse range of design strategies can accommodate the needs of various user groups from differing cultures and demographics and create an environment that is psycho-physiologically and cognitively restorative. For instance, vegetated spaces can improve an individual’s self-esteem and mood, while the presence of water can have a relaxing effect. Multisensory experiences, such as having visual and physical access to vegetated spaces with a water feature, may achieve those outcomes at a more profound level.

This ‘layering’ of patterns is similar to the approach to that planting species in a planting scheme that remains responsive and adaptive to changes in seasons and environments.

For example, a design scheme that supports a Visual Connection with Nature would need to also consider seasonal changes, diurnal cycles, drought, maintenance, use patterns, and other potential factors that affect the biophilic properties of the space, as well as its efficacy over time. The incorporation of secondary, supportive or latent patterns can ensure the space remains adaptive to these changes and provides restoration.

- Dominant / Primary patterns are incorporated to trigger desired experience or health response.
- Supportive / Secondary patterns either provide co-benefits to restoration or enhance restorative properties of the Dominant / Primary pattern, such as to support a multisensory experience.

The objective is not to include all patterns, but to identify the most critical to ensuring the desired experience and health outcome. Secondary patterns may be ephemeral—seasonal or time bound. If a pattern can be removed from a design scheme without having a meaningful impact to the experience, then it probably isn't necessary.

Quality versus quantity of intervention

When planning for implementation, common questions recur, such as 'How much is enough?' and "What makes good design great?'. A high quality intervention may be defined by the richness of content, user accessibility and, as mentioned above, diversity or layering of strategies. A single, high-quality intervention can have greater restorative potential than several low-quality interventions. For instance, one potted plant in each office is unlikely to have as profound an impact as assembling all those plants together in an office communal area designed to support frequent use.

Climate, cost, and other variables may influence or limit feasibility of certain interventions, but should not be considered an obstacle to achieving high-quality application. For example, multiple instances of Prospect with a shallow to moderate depth of field and limited information in the viewshed may not be as effective (at prompting the desired response) as a single powerful instance of Prospect with a moderate to high depth of field and an information-rich viewshed. See also "Controlling for efficacy" in the following pages.

Duration of exposure and frequency of access

What's the optimal dosage of nature needed to ensure healthy childhood development and a healthy livework life for adults? The ideal exposure time is likely dependent on the user and the desired effect, but working from a baseline, there is enough research available to provide general guidelines.

Exposure on an hourly basis or regularly throughout the day to lower and minimize stress, reduce mental and ocular fatigue, regain or maintain attention. Here are some examples from research:

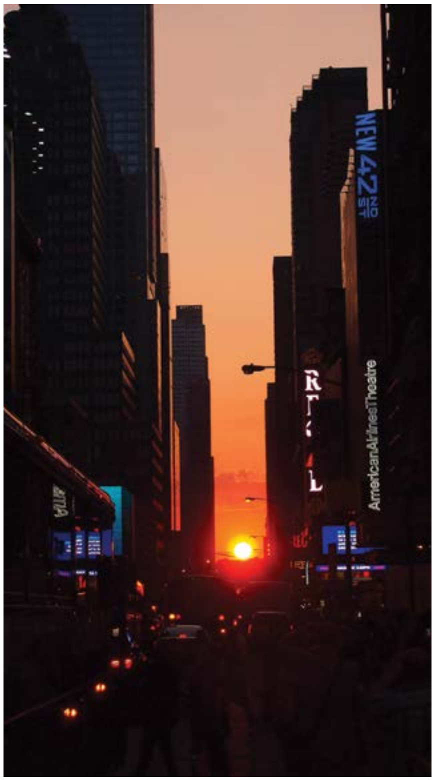
- **40 seconds** to trigger restoration of cognitive capacity (Lee et al., 2015).
- **5 minutes** to positively impact mood (Barton & Pretty, 2010).
- **10 minutes** to stimulate heart rate variability and parasympathetic activity (i.e., regulation of internal organs and glands that support digestion and other activities that occur when the body is at rest) (Brown, Barton & Gladwell, 2013).

Biophobia & Ecophobia

Biophobia is a fear of or aversion to nature or living things (Ulrich, 1993). Similarly, ecophobia refers to an unreasonable but deeply conditioned disgust for or reaction against natural forms or places.

While biophobia is arguably genetic, to a degree, both phobias are learnt response mechanisms through direct experience, culture and education which, according to Salingaros and Masden (2008), includes architectural education.

The most common biophobic responses are to spiders, snakes, predators, blood, and heights – elements that either directly threaten or signal danger through humanity's evolutionary path. When tempered with an element of safety (e.g., railing or glass window), however, the experience can be transformed into one of curiosity, exhilaration and even a type of mind-body systems recalibration.



Manhattanhenge is a twice a year awe-inducing experience where the setting sun aligns with the New York City grid—thousands of people take to the streets to witness and photograph the moment. This type of alignment with natural cycles was created intentionally among ancient civilizations, is a rarity among modern structures. Image courtesy Andreas H. from Unsplash

- **20 minutes** to return cerebral blood flow and brain activity to a relaxed state (e.g., Tsunetsugu & Miyazaki, 2005).
- **60 minutes** of exposure to boost creativity, restore heart rate and blood pressure, lower cortisol levels (e.g., Determan et al., 2019).
- **2–3 days** of continued immersion to boost immune cells (e.g., Qi, 2009).

Empirical evidence shows that positive emotions, mental restoration, and other benefits can occur in as little as 5 to 20 minutes of immersion in nature (e.g., Brown, Barton & Gladwell, 2013; Barton & Pretty, 2010; Tsunetsugu & Miyazaki, 2005). It's important to note that the many research studies assessing exposure impacts each focused on differing metrics measuring health impacts, with participants being exposed to a variety of sensory characteristics in nature. Therefore, duration should be regarded as a general parameter rather than a determinant of success.

When a long duration of exposure is not possible or desired, positioning biophilic design interventions along paths that channel high levels of foot traffic will help improve frequency of access. Consider too that those micro-restorative experiences—brief sensory interactions with nature that promote a sense of well-being—while often designed in response to budget and space restrictions, are more readily implementable, replicable and often more accessible than larger interventions. Frequent exposure to these small interventions may contribute to a compounded restoration response.

Viewing of the same information-rich nature scene, like a Japanese garden, has been noted to maintain roughly the same level of interest over time (Biederman, 2006). Indoors, biometric evidence from studies of a biophilic classroom (Determan, et al. 2019) and an immersive biophilic experience in a hospital breakroom (Putrino, et al. 2020) indicate that positive physiological and psychological responses can improve over repeated exposures.

University of Virginia colleagues Tanya Denkla-Cobb and Timothy Beatley formulated early expressions of recommended doses of nature across scales—as a Nature Pyramid—that have since been adapted for many public health nature literacy initiatives (Beatley, 2016). Nature doses at the Daily and Weekly scales are achievably for the built environment, while longer dosages (e.g., 2 days immersion) are perhaps more practical for pursuing outside the urban setting.

Locally Appropriate Design

No two places are the same, presenting both challenges and opportunities for creativity in the application of biophilic design patterns. Discussed here are some key considerations that may help frame, prioritize, or influence decision making in the design process.

Climate, ecology and the vernacular

Historically, humans have built shelters from locally available materials that inherently reflected the regional ecology—form and function were in response to the topography and climate. Known as vernacular architecture, these buildings and constructed landscapes connect to where they inhabit.

Use of local timber, climate responsive design, and xeriscaping (constructing landscapes with climate approapriate species that require little to no irrigation) can be effective strategies in designing for a biophilic experience, even if not technically vernacular by design. Intentionally variable airflows in cross ventilation and mechanical design, and mixing surface materials that have differing thermal conductance, can help achieve an experience more reflective of traditional vernacular structures.

Contemporary practice tends to gravitate toward tropical solutions for biophilia—indeed there are many fantastically verdant examples from Equatorial countries—which are not responsibly replicable in water–strapped communities. More critically, whether rural or urban, not all natural or tempered environments are 'green' in color, nor should they be. Desert species and terrain can be equally important in reinforcing a biophilic connection to place. Some habitats may engender a stronger positive response than others, but a small biodiverse oasis or savanna–like scene are likely preferred over an abundant yet trackless sand desert or a dark forest.

Character and density: Rural, suburban, and urban environments

In rural environments, human-nature interactions are abundant, and this regular exposure to nature has restorative qualities that have long been taken for granted. Suburban settings are typically rife with intuitively applied biophilic design; the suburban yard with shade trees, grass, low shrubs, and beds of flowers is essentially an analogue of the African savanna. Porches and balconies offer more than just quaintness and real estate value; many suburban homes and urban rowhouses are raised 18 inches or more—a flood prevention tactic that also creates a prospect–refuge condition with views from windows, stoops and porches.

In high-density settings, residences with yards, balconies and occupiable rooftops are too often only accessible to high–paying buyers and tenants. As the human health benefits become more valued in real estate, growth in demand follows with occupiable outdoor space, greenroofs, and other outdoor amenities becoming available to many more economic segments. There is a danger, however, in relying on juliet balconies and poorly articulated roof decks as "outdoor space" when such precipitous interventions inadvertently thrust occupants into a sensory overload characterized by traffic sounds, smog, air conditioning units, or unsightly views. In such cases, a balcony does not truly support a connection with nature.

Material Connection with Nature and other patterns can be applied across all climates and environments, but may have different resulting forms, aesthetics and materials specific to their respective regions.

From top to bottom: **Tucson Mountain Home** by Rick Joy, courtesy Pröhl; **Thorncrown Chapel** by E. Fay Jones, © informedmindstravel/Flickr; **New Gourna** by Hassan Fathy, © Marc Ryckaert; **Thatched roof** construction, © Colin Cubitt/Flickr.

Tsukubai basins, essential fixtures of traditional Japanese tea gardens, are frequently featured along contemporary garden pathways and entryways to restaurants, offices and homes, visible and audible to passersby, offering a serene sense of welcome. Image © Bill Browning

Land in urban environments is limited and at a premium, so it may be unrealistic to replicate features more suitable to a rural environment in terms of scale or abundance. As such, biophilic design strategies will differ depending on the local political climate, zoning, geography, land availability and ownership. For instance, San Francisco, with its high-density urban form, implemented a 'parklet' system, whereby temporary pop-up parks occupy parking spaces for limited periods of time (see City of San Francisco, 2013). In the narrow streets of Vienna, Austria, restaurants rent parking spaces for the entire summer and set up tables and temporary landscaping to provide outdoor dining. This brings nature into the urban core and within walking distance to a greater number of people, opening up the possibility for micro-restorative experiences and a reclamation of underutilized space for people.

A different approach to integrating natural systems with urban systems is exhibited in Singapore's 'Skyrise Greenery' program. Given the high levels of development in tropical Singapore over the last 25 years – a period which saw the country's populations grow by two million people – the government offered an incentive program to offset the loss of habitat, increase interaction with natural stimuli, and create the 'City within a Garden'. This incentive program offers up to 75% of the costs for installing living roofs and walls (exterior and interior) for new constructions (Beatley, 2016). What's important is that the strategy be integrative and appropriate to the character and density of the place, and not just another word for ecosystem restoration that does not reflect the human biological relationship with nature.

Scale and feasibility

Biophilic design patterns should be scaled to the surrounding environment and to the predicted user population for the space. Patterns can be applied at the scale of a micro-space, a room, a building, a neighborhood or campus, and even an entire district or city. Each of these spaces will present different design challenges depending on the programming, user types and dynamics, climate, culture, and various physical parameters, as well as existing or needed infrastructure.

Aerial view of the expansive General Motors Tech Center designed by Eero Saarinen. The campus is meant to be experienced at 30 mph along the highway, not at the pedestrian speed of 2–3 mph. Image © Donald Harrison/Flickr.

Size and availability of space are two of the most common factors influencing feasibility of biophilic design patterns. For instance, the Prospect pattern [P11] typically requires significant space. Other patterns, such as Connection with Natural Systems [P7], may be more feasible where there is access to an outdoor space, which is a common challenge in dense urban environments. Yet small scale, micro-restorative Visual [P1] and Non-Visual Connections with Nature [P2] and Presence of Water [P5] can also be very effective. For instance, the psychological benefits of nature actually have been shown to increase with exposure to higher levels of biodiversity (Fuller el al., 2007), yet these benefits do not necessarily increase with greater natural vegetative area. From this we can derive that small, micro-restorative experiences that are also biodiverse are likely to be particularly effective at engendering a restorative biophilic experience.

Micro-restorative might include moments of sensory contact with nature through a window, television, image, painting or an aquarium. In urban environments where sensory overload is common (Joye, 2007), such experiences will be most valued and impactful when situated in locations with high foot traffic, allowing for a greater frequency of access to trigger the desired biophilic response. Traditional Japanese doorway gardens are a perfect example of replicable small-scale interventions.

The speed at which one moves through an environment, whether rural or urban, impacts the level of observable detail and the perceived scale of buildings and spaces. The General Motors “Tech Center” in Warren, Michigan, designed by architect Eero Saarinen in 1949, is designed to be experienced at 30 mph, so for the pedestrian, the scale seems oversized and the spacing of buildings is oddly far apart. This is why stores on along strip malls have large, simple façades and signage, whereas stores within pedestrian zones tends to have smaller and perhaps more intricate signage. Similarly, the landscaping along freeway and highway greenbelts is typically done in large swaths for instant interpretability. In contrast, a pedestrian focused environment will have more fine-grained details in the landscape design to allow for pause, exploration, and a more intimate experience.

Some patterns, such as [P13] Mystery and [P14] Risk/Peril, might not be as feasible or cost-effective in an interior fit-out project because of the amount of space required to effectively implement the pattern. On the other hand, interior fit-outs are an excellent opportunity to introduce Natural Analogue patterns which can be applied to surfaces like walls, floors, and ceilings as well as furniture and window treatments. In addition, not all aspects of biophilia are space dependent. Some patterns (e.g., P2, P4, P6, P7) are more visceral or temporal, requiring little to no floor area, and other patterns (e.g., P8–P10) may simply guide design choices that were already a part of the design process.

Major renovations, new construction and master planning provide more opportunities for incorporating biophilic design patterns that are coupled with systems integration at the building, campus or community scale.

Culture, demographics, and inclusiveness

Current evolutionary hypotheses and theories state that contemporary landscape preferences are influenced by human evolution, reflecting the innate landscape qualities that enhanced survival for humanity through time. These schools of thought include the biophilia hypothesis (Wilson, 1993; Wilson, 1984), the savanna hypothesis (Orians & Heerwagen, 1992), the habitat theory and prospect–refuge theory (Appleton, 1977), and the preference matrix (R. Kaplan & Kaplan, 1989). While empirical research has shown that there is a degree of universality to landscape preferences

Environmental Generational Amnesia

One of the cultural challenges to upholding that human-nature bond, as well as environmental stewardship, is a phenomenon known as Environmental Generational Amnesia, the shifting baseline for what is considered a normal environmental condition as it continues to degrade. As environmental degradation continues, the baseline continues to shift with each ensuing generation, each perceiving this degraded condition as the norm or non-degraded condition.

This shifting baseline varies across cultures, geographic regions and sub-groups (Kahn, Severson & Ruckert, 2009), influencing environmental stewardship, proximity and access to nature and the biophilic experience. Helping a community to understand what their home looked like when it was a healthy, intact ecosystem is one way of making a Connection with Natural Systems and will hopefully help foster and frame the importance of other areas of environmental quality.

Merstham Park was deliberately designed to enhance views of the UK's Surrey countryside, and to serve as a destination and immersive multisensory experience for the neighborhood school and community. Photo © Marianne Majerus Garden Images.

among humans, preferences have been modified by cultural influences, experiences and socio-economic factors (Tveit et al, 2007). Variations in landscape preferences have thus emerged among immigrants, ethnic groups, subcultures, genders, and age groups.

Cultural constructs, social inertia, and ecological literacy suffuse differing perspectives on what constitutes natural, nature, wild, or beautiful (Tveit et al., 2007; Zube & Pitt, 1981). Concepts of **environmental generational amnesia** and **ecological preference and neuroaesthetics** help explain how perspectives may have evolved, and these differences come to bear across countries and regions, and in neighborhoods within the same city.

And while ethnicity can play a role in influencing an individual's landscape preferences, cultures and groups across the world utilize landscapes and space in different ways (e.g., Forsyth & Musacchio, 2005). Frequency of use, nature of use, participation rates and purpose of visit all vary drastically between nationalities, cultures and sub-groups. These factors do not mean that certain ethnic groups have a lower appreciation for landscape or a less significant connection with nature. These groups simply utilize and interact with nature in ways that are compatible with their culture and needs. Identifying early on what those needs may be will help define parameters for appropriate design strategies and interventions.

Age and gender are also known to influence biophilic response trends. Women report higher perceived levels of stress than men, yet are less likely than their male counterparts to use available natural outdoor vegetative space during the work day (Lottrup, Grahn & Stigsdotter, 2013). Of particular interest is that the degree of enhanced immune function due to immersion in nature has been observed to differ between the genders. For instance, following a nature immersion, immune function was increased for a period of 30 days in men, but only seven days in women (Li, 2010), suggesting that interventions targeting female populations in the workplace may need to either prioritize indoor nature experiences or improve accessibility for prolonged outdoor nature experiences.

Youth benefit the most from nature contact in terms of increasing self-esteem. The gains for self-esteem from nature contact are suggested to decline with age; elderly and youth benefit the least in terms of mood enhancement from nature contact (Barton & Pretty, 2010), yet both groups are equal in perceived restorativeness of natural over urban environments (Berto, 2007). With age also comes a differing preference in landscape in regards to perceived safety. While an urban woodland may be an enticing place for adventure for a child or teenager, the same condition could be perceived by adults and elderly populations as risky (Kopec, 2006), which could possibly be overcome by incorporating a Prospect–Refuge condition.

Design Integration

Interdisciplinary planning and design

Developing an interdisciplinary strategy early on in a project will help ensure cost-effective opportunities are not lost before they are fully considered. Biophilia is but one piece of the puzzle to creating a vibrant, sustainable, and restorative environment.

An interdisciplinary strategy in the early stages of development, through a stakeholder charrette process or similar, will put team members on equal footing and allow for the identification of potential strengths, challenges and opportunities. In the long run, this approach will improve project satisfaction and save money.

Factoring in other agendas, such as biodiversity or green area legislation, carbon and climate action plans, public health targets, and so on, adds a rich perspective and validation to the potential biophilic design solutions under consideration. Authentic integration can also help mitigate risk of cost engineering biophilic solutions out of a project.

In the UK, for instance, new legislation requires a minimum of 10% Biodiversity Net Gain (BNG) post-development for any projects requiring planning approval. By embedding biophilic design in BNG interventions, the requirement would be met while supporting public health priorities and the like.

Biophilia as an environmental quality

Environmental quality is an umbrella term that refers to the sum of the properties and characteristics of a specific environment and how it affects human beings and other organisms within its zone of influence. Biophilia, like air quality, thermal comfort and acoustics, is an essential component of environmental quality that expands the conversation from daylight, materials toxicity, and air, water and soil quality, to include human biological health and well-being and, ideally, environmental awareness and stewardship.

Green building standards and rating systems (e.g., LBC, LEED, WELL, Building With Nature) have incorporated features and credits that revolve around nature-based conditions for occupant well-being.

When integral to the environmental quality discussion, biophilia may also help dissolve the perceived division between human needs and building performance. We would be remiss not to acknowledge that back-of-house and night shift workers—usually the very people responsible for monitoring and maintaining building and operational performance—are often the most deprived of biophilic experiences. From an architectural perspective, biophilic design patterns have the potential to refocus the designer's attention on the links between people, health, high-performance design, and aesthetics.

Ecological Preference & Neuroaesthetics

Learned preferences, existing health baselines, accessibility, demographics and cultural backgrounds shape our perception of nature and aesthetics. Whilst cultural background and ecological literacy have been explored as predictors of spatial preference (e.g., Forsyth & Musacchio, 2005; Nassauer, 1995; Balling & Falk, 1982), contemporary discussions reflect equity, inclusiveness, and neuroaesthetics.

Neuroaesthetics is an emerging field which seeks to understand how our brain responds to physical environments and how long we choose to spend in them, with the aim of informing environmental design to enhance human health and well-being (Coburn, 2022; Coburn, Vartanian & Chatterjee, 2017). Neuroasthetics research that looks at responses to spiritual and secular spaces suggests that adopting spatial elements of spiritual spaces into secular environments can enhance calm and opportunities for reflection and restoration (Bermudez et al., 2017). See also pattern #15 Awe and Thin Place Design by Phillip James Tabb (2023).

As there is no universal preference for a specific type or form of "natural" environment, this research leads us to consider how we might tailor interventions to specific demographics. To do so, biophilic design solutions must be a in response to context – which includes the local ecology and people – to produce appropriate and "preferred" spaces.

At Prisma in Germany, a biocentric solution to rainwater management enabled integration with building systems and art installations, as well as year-round experiences of nature through dynamic indoor landscaping. Image courtesy Doug Hill for Rocky Mountain Institute.

Multilateral and biocentric solutions for co-benefits

Thoughtful applications of biophilic design can help enable or validate multilateral solutions at the building scale that overcome familiar challenges traditionally associated with building performance such as thermal comfort, acoustics, energy and water management. Increased natural air flow is known to help prevent sick building syndrome; daylighting can cut energy costs for heating and cooling (e.g., Loftness & Snyder, 2008); and increased vegetation can reduce particulate matter in the air, reduce urban heat island effect, improve air infiltration rates and reduce perceived levels of noise pollution (Forsyth & Musacchio, 2005). These strategies can all be implemented in a manner that achieves a biophilic response for improved performance, health and well-being.

Biophilic design interventions that are integrated with other building performance strategies have the potential to improve user experience and overall systems efficiency, as well as persist over time. Herbert Dreiseitl's design for Prisma in Nürnberg, Germany, includes sculptural water walls that serve as both a thermal control device and exposed rainwater conduit, while contributing to the visual and acoustic ambiance of the enclosed garden atrium. For the design of the Khoo Teck Puat Hospital in Singapore, RMJM architects and CPG Consultants met with ecologists and engineers early in the project development process to employ biophilia, ecological conservation and water sensitive urban design to manage rainwater, mitigate loss of biodiversity and create a restorative environment for patients, reaping more benefits for the project than any one of the three teams could have on their own (Alexandra Health, 2013).

At this broader scale, biophilic design can be used to help confront larger, biocentric issues such as biodiversity and wildlife habitat, materials sourcing, natural hazard resilience, environmental restoration. In taking such a biocentric outlook, biophilia could then be framed as an ecosystem service—as the direct and indirect health benefits that humans receive from healthy ecosystems are plentiful. **Biocentric design** thereby offers a more holistic approach to embedding biophilic experiences solving for societal ailments, while advancing creative solutions that work toward regenerative development and natural environment preservation.

Have we done enough and will it last?

Biophilia is not an exacting science, yet most biophilic design is good for most people. A biophilic design intervention doesn't need to be perfect to be effective, but it does need to be thoughtfully executed for the effect to persist in a meaningful way.

Controlling for efficacy

Given that the needs, preferences and priorities of a person or group of people are in constant flux, it is a complex notion that an intended experience or health outcome can be guaranteed. As certain types of outcomes cannot be confirmed without post-occupancy testing and evaluation, which can sometimes be invasive or cost prohibitive, quality assurance and demonstration of compliance with expectations often need to be attained by other means. (See earlier subsection of "Planning for Integration".)

Certainly, some assumptions are quite realistic. For instance, we can comfortably assume that the efficacy of some biophilic patterns will rise and decline with diurnal and seasonal cycles. The health benefits of a view to nature may be diminished during winter months or completely negated for night shift workers when the view is shrouded in darkness. Awareness of such circumstances allow the opportunity for secondary or seasonal strategies—as well as user engagement—that help maintain balance and equity of benefits throughout spaces, across populations, and over time.

User controls for lighting, heating, cooling, ventilation, and even noise can either complement design efforts, or negate them when controls are mismanaged or underutilized – specifying high partitions in an open plan office eliminates opportunities for Prospect and Dynamic Light, and keeping opaque window blinds closed all day eliminates a Visual Connection with Nature, as well as the health benefits that come with each of these patterns.

Who will be responsible for opening the window blinds, watering the plants, or cleaning the fish tank, and why should they bother? Facility operators, management level stakeholders, and user/occupants are more likely to be stewards of a biophilic experience when the design intent and health impact are understood.

- Engage facility operators and department managers in the design process to help shed light on potential maintenance challenges or reveal new efficiencies.
- Design/build/program in cues and affordances to a biophilic intervention that help stewards continually optimize durability, persistence, and quality of the user experience.
- Host trainings and discussions with facility operators, office/building/land managers, and users.
- Provide a reference guide that indicates experiential design intent and appropriate maintenance measures requirements.

Tracking and measuring efficacy

The science of biophilia is a continuously evolving area of intrigue, with outputs rapidly growing in biophilia-related research in psychology, neuroscience, endocrinology and other fields. As a branch of inquiry, applied science initiatives continue to expand to monitor the efficacy of implemented biophilic design patterns for the express purpose of improving health and well-being in the built environment. A common theme encountered over the last 10 years has been a lack of post-occupancy evaluation (POE) or consistent long-term monitoring and evaluation. Anecdotal evidence suggests that POEs are often planned for but are frequently cut when other

Biophilic, Biocentric & Regenerative Design

Biocentrism is an ethical perspective directing that "all life deserves equal moral consideration or has equal moral standing" (Encyclopedia Britannica).

While biocentrism has practical implications for human behavior (and a plethora of laws and policies), biocentric design can inform our approach to land planning, development, and design at an ecosystem level (and well beyond), and can be more holistic than biophilic design that may be narrowly focused on an individual space or experience.

With this outlook, biocentric design is ideally untethered by anthropogenic constructs (e.g., land ownership, regulatory boundaries) so familiarly imposed on a single building or site.

It could be said that as we continue to grasp the science of biophilia—the many ways in which humans are intrinsically connected to nature and living things—we are opening our minds to biocentric design and stewardship, which is one step closer to truly regenerative design that works with natural ecosystems and improves the health of people and planet.

See also Five key principles in designing regenerative buildings (Eddy Santosa for USGBC, 2024) and *The Grand Biocentric Design, How Life Creates Reality* (Lanza, Pavsic & Berman, 2021).

aspects of the project exceed the budget. Before undertaking cost-cutting measures, clients and project teams should consider:

- How will data be collected to demonstrate returns on investment, performance improvements, and business cases for future biophilic projects?
- How can compliance/achievement be demonstrated with client brief and design intent alone?
- How can assurances be provided for the design to remain restorative and effective over time?

The rising profile of biophilic design over the last decade has also resulted in a globally wider, intentional implementation. This rise has yielded more diverse data, lessons learned, and new approaches to biophilic design that reflect a project's context and end user's experience and needs. The tracking and monitoring of human biological responses and outcomes, triggered by a biophilic pattern, are recognized by many as being vital in furthering the development of biophilic design as a best practice.

However, as no two projects, interventions or user groups will be the same, research results will undoubtedly differ to one degree or another. Variables in the built environment, such as those discussed in this chapter, present a challenging framework for verification and a labyrinth of data for comparison. Quantitative metrics are often desired but not always appropriate, and the highly intensive nature of some measurement techniques and tools adds layers of complexity and cost. Despite these constraints, new approaches have become more readily accessible:

- Smart watches and smart phone-enabled sensors enable real time and aggregregated data collection;
- Virtual reality systems with gaze attention tracking allows for predictive responses to biophilic interventions in proposed designs (e.g., Yin et al., 2020);
- Advanced mobile electroencephalogram (EEG) equipment explores rapid subconscious response to specific three-dimensional spaces that have been predicted in Affordance Theory research (e.g., Djebbara, 2018); and
- Functional magnetic resonance imaging (fMRI), used for Neuroaesthetics research and is focused exclusively on the brain, teases out responses that may be to be tied to specific demographics (e.g., Bermudez et al., 2017).

Increased affordability to such sophisticated equipment has opened the field to new possibilities for the study of biophilic responses to an array of stimuli and environments. This research continues to fuel our understanding of these biophilic design patterns, which are refined and substantiated as new evidence comes to light. From this iterative process, one new pattern has already emerged since the original edition of this publication (see pattern #15, Awe) and it is entirely possible that additional patterns will emerge over time with sufficient research.

Designed by WOHA, the PARKROYAL COLLECTION hotel on Pickering Street in Singapore manages local rainwater and extends urban biodiversity while providing a series of bespoke biophilic guest experiences, most notably, multisensory connections with nature, water, biomorphic forms, and perceptions of risk. Image courtesy Bill Browning.

The Patterns

Pattern as Precedent

In the four decades since Edward O. Wilson published *The Biophilia Hypothesis*, the body of evidence supporting biophilia has expanded considerably. Biophilic design patterns identified in this publication have been, in the words of Wilson, "teased apart and analyzed individually" to reveal emotional affiliations Wilson spoke of, as well as other psychophysiological and cognitive relationships with the built environment. The descriptive term 'pattern' has intentionally been used for three reasons:

- to propose a clear and standardized terminology for biophilic design;
- to avoid confusion with multiple terms (metric, attribute, condition, characteristic, typology, etc.) that have been used to explain biophilia and biophilic design; and
- to maximize accessibility across disciplines by upholding a familiar language.

The use of spatial patterns is inspired by the precedents of *A Pattern Language* (Alexander, Ishikawa, Silverstein et al., 1977), *Designing with People in Mind* (Kaplan, Kaplan, & Ryan, 1998) and *Patterns of Home* (Jacobson, Silverstein & Winslow, 2002), as well as lectures and compilations on patterns, form, language and complexity (Mehaffy et al., 2020; Salingaros, 2000 and 2013). Christopher Alexander brings clarity to this intent with his explanation that patterns...

> *"...describe a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice."*

Alexander's work built on the tradition of pattern books used by designers and builders from the eighteenth century onward, but his work focused on the psychological benefits of patterns and included descriptions of the three dimensional spatial experience, rather than the aesthetic focus of previous pattern books. This publication focuses on the evidence-based psychological, physiological and cognitive benefits of 15 patterns from three experiential conditions of nature.

"...Biophilia is not a single instinct but a complex of learning rules that can be teased apart and analyzed individually. The feelings molded by the learning rules fall along several emotional spectra: from attraction to aversion, from awe to indifference, from peacefulness to fear-driven anxiety."

Edward O. Wilson, 1993
Biophilia and the Conservation Ethic, *The Biophilia Hypothesis*

Patterns or Principles?

In 2015, after the 14 Patterns of Biophilic Design had taken root, Stephen Kellert and Elizabeth Calabrese articulated five Principles of Biophilic Design (Kellert & Calabrese, 2015).

1. Biophilic design requires repeated and sustained engagement with nature.
2. Biophilic design focuses on human adaptations to the natural world that over evolutionary time have advanced people's health, fitness and wellbeing.
3. Biophilic design encourages an emotional attachment to particular settings and places.
4. Biophilic design promotes positive interactions between people and nature that encourage an expanded sense of relationship and responsibility for human and natural communities.
5. Biophilic design encourages mutually reinforcing, interconnected, and integrative architectural solutions.

While there exist other lists with even more principles, these five give a sense of how design principles and patterns differ. Principles are broadly applicable to nearly any project anywhere, irrespective of the user group, climate, culture, urban condition and are, ideally, all aspired to on a given project.

Patterns, however, are more directly associated with specific design interventions or strategies that will undoubtedly differ from one project to the next, depending on the user group, climate, culture, and urban condition.

Working with Biophilic Patterns

While informed by science, biophilic design patterns are not formulas; they are meant to inform, guide and assist in the design process and should be thought of as another tool in the designer's toolkit. The purpose of defining these patterns is to articulate connections between aspects of the built and natural environments and how people react to and benefit from them.

After each pattern is defined, it is then discussed in terms of the following:

- The Experience briefly considers how the pattern might impact the way a space feels;
- Roots of the Pattern highlights key scientific evidence that relates human biology to nature and the built environment;
- Working with the Pattern highlights design attributes, examples, and considerations; and
- Relation to Other Patterns briefly notes opportunities for integrative biophilic design strategies.

Just as combinations of culture, demographics, health baselines, and characteristics of the built environment can impact the experience of space differently, so too can each design pattern. A suitable solution results from understanding local conditions and one space's relationship to another, and responding appropriately with a combination of design interventions to suit the unique needs of a space and its intended user group and programs.

Finally, each pattern has been assessed for overall potential impact and the strength of the research on which a pattern is built. Unless otherwise noted, all examples reported are based on data published in a peer-reviewed journal. We acknowledge that some studies are more rigorous than others and that some patterns have a greater body of research to support findings of significance. To help communicate this variability, up to three asterisks are following each pattern name, whereby three asterisks (***) indicates that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is adequate for hypothesizing its potential impact and importance as a unique pattern.

The field of biophilic design is constantly evolving, and as Salingaros (2000) explains, new disciplines such as biophilic design must "abstract its patterns as they appear… building its own foundation and logical skeleton, upon which future growth can be supported." As new evidence comes to bear, it is entirely possible that some patterns will be championed over others and that new patterns will emerge. By establishing these patterns, we hope to encourage the widespread scientific study, discussion, and implementation of biophilic design.

14+ Patterns of Biophilic Design

Improving Health and Well-Being in the Built Environment

Nature in the Space

1. Visual Connection with Nature
   A view to elements of nature, living systems and natural processes.

2. Non-Visual Connection with Nature
   Auditory, haptic, olfactory, gustatory, or thermal stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.

3. Non-Rhythmic Sensory Stimuli
   Stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely.

4. Thermal & Airflow Variability
   Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.

5. Presence of Water
   A condition that enhances the experience of a place through the seeing, hearing or touching of water.

6. Dynamic & Diffuse Light
   Leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature.

7. Connection with Natural Systems
   Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.

Natural Analogues

8. Biomorphic Forms & Patterns
   Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature.

9. Material Connection with Nature
   Material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place.

10. Complexity & Order
    Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.

Nature of the Space

11. Prospect
    An unimpeded view over a distance for surveillance and planning.

12. Refuge
    A place for withdrawal, from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.

13. Mystery
    The promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.

14. Risk/Peril
    An identifiable threat coupled with a reliable safeguard.

15. Awe
    Stimuli that defy an existing frame of reference and lead to a change in perception.

Pattern 1

Visual Connection with Nature

* * *

A view to elements of nature, living systems and natural processes.

Top: Kikugetu-tei, Takamatsu, Japan. Image © wakiiii/Flickr.

Researched benefits to...

PHYSIOLOGICAL: Stress levels, Stress recovery, Blood pressure, Heart rate, Heart rate recovery

PSYCHOLOGICAL: Emotional functioning, Visual preference, Sadness, Anger, Aggression, Attitude, Happiness

COGNITIVE: Mental engagement Interest, Attentiveness and attentional fatigue, Concentration

The Experience

A space with a good Visual Connection with Nature feels information rich; it grabs one's attention, can be stimulating or calming; and can convey a sense of time, weather, and hint at the presence of other living things.

Roots of the Pattern

The Visual Connection with Nature pattern has evolved from research on visual preference and responses to views to nature that have resulted in reduced stress, more positive emotional functioning, and improved concentration and recovery rates. Stress recovery from visual connections with nature have been realized through lowered blood pressure and heart rate; reduced attentional fatigue, sadness, anger, and aggression; improved mental engagement/attentiveness, attitude and overall happiness. There is evidence for stress reduction related to both experiencing real nature and seeing images of nature. The psychological benefits of nature are evidenced to increase with higher levels of biodiversity, but not necessarily with higher quantities of vegetated area (Fuller et al., 2007).[1a]

Visual preference research indicates that the preferred view is looking down a slope to a scene that includes multiple copse of shade trees, flowering plants, calm non-threatening animals, indications of human habitation, and bodies of clean water (Orians & Heerwagen, 1992). The degree of impact and time exposure thresholds tend to vary—from 40 seconds to 20 minutes to two days—depending on the measurements and experiences being studied.[1b] (See also "Duration of exposure and frequency of acces" in the first section of this book]. This variability makes it tricky to pin down decisive design parameters, yet rife with opportunity for creative experiential design.

Another area of influence is simulated nature, particularly when living, biodiverse and dynamic nature is not available. Viewing scenes of nature stimulates a larger portion of the visual cortex than non-nature scenes, which triggers more pleasure receptors in our brain, leading to prolonged interest and faster stress recovery. Heart rate recovery from low-level stress can occur 1.6 times faster when there's a nature view through a glass window, rather than a high-quality simulation (i.e., plasma video) of the same nature view, or no view at all (Kahn et al., 2008). Additionally, unlike with repeated viewing of non-nature, the impact of repeatedly viewing real nature does not significantly diminish a person's level of interest over time (Biederman & Vessel, 2006).

Working with the Pattern

The objective of the Visual Connection with Nature pattern is to provide an environment that helps the individual shift focus to relax the eye muscles and temper cognitive fatigue. The effect of an intervention will improve as the quality of a view and the amount of visible biodiversity increase.

A view to nature through a window provides a benefit over a digital screen (e.g., video/plasma TV) of the same view, particularly because the viewer experiences no parallax shift as they move toward or around a video screen (Kahn et al., 2008). Responses to viewing Virtual Reality displays of nature—with parallax and other illusionary characteristics—more closely match viewing living nature and can be used as a tool to gauge effectiveness of biophilic design measures (Yin et al., 2018; Yin et al., 2020). Nevertheless, simulated and living nature are likely to be measurably better at engendering stress reduction than having no visual connection at all.

Design considerations for establishing a strong visual connection with nature:

- Prioritize real nature over simulated nature; and simulated nature over no nature. The benefits of viewing real nature may be attenuated by a digital medium, which may be of greatest value to spaces that, due to the nature of its function (e.g., hospital radiation units) cannot easily incorporate real nature or views to the outdoors.
- Orient seating to face nature, rather than presenting nature as a backdrop.
- Prioritize biodiversity over acreage, area or quantity.
- Prioritize or enable exercise opportunities that are in proximity to green space.
- Design to support a visual connection that can be experienced for at least 5–20 minutes per day.
- Design spatial layouts, partitions, and furnishings to uphold desired view lines and avoid impeding the visual access when in a seated position.
- Even small instances of nature can be restorative, and particularly relevant for temporary interventions, or spaces where real estate (floor/ground area, wall space) is limited.

An example of a designed environment with an excellent Visual Connection with Nature is the birch tree and moss garden in the New York Times Building in New York City – a carved out space in the middle of the building by which everyone passes as they enter or leave the building. Adjacent to a restaurant and the main conference rooms, the birch garden is an oasis of calm in the hustle and bustle of Times Square.

Example Characteristics

Naturally Occurring

- Natural flow of a body of water
- Vegetation, including food bearing plants
- Animals, insects
- Fossils
- Terrain, soil, earth

Simulated or Constructed

- Mechanical flow of a body of water
- Koi pond, aquarium
- Green wall
- Artwork depicting nature scenes
- Video depicting nature scenes
- Curated landscapes

Above: The NY Times Building moss and birch garden, provides a visual (though not a multisensory) connection with nature from various vantage points throughout the building. New York by Renzo Piano acts as an oasis of calm. Image © Hubert J. Steed.

Non-Visual Connection with Nature

* * *

The auditory, haptic, olfactory, gustatory, or thermal stimuli that engender a deliberate and positive reference to nature, living systems, or natural processes.

Top: Morske Orgulje (sea organ) experiential marble steps in Zadar, Croatia. Designed by architect Nikola Bašić. Image © Bohringer Friedrich.

Researched benefits to...

PHYSIOLOGICAL: Systolic blood pressure, Stress hormones, Energy restoration, Relaxation/ Cerebral blood flow rates, Joint flexibility, Perceived pain

PSYCHOLOGICAL: View perception, Perceived mental health, Calming, Perceived tranquility, Well-being, Environmental stewardship, Restoration, Self-reported fatigue

COGNITIVE: Performance, Fatigue, Motivation

The Experience

A space with a good Non-Visual Connection with Nature feels fresh and well balanced; the ambient conditions are perceived as complex and variable but at the same time familiar and comfortable, whereby sounds, aromas, textures, and thermal qualities are reminiscent of being outdoors in nature.

Roots of the Pattern

The Non-Visual Connection with Nature pattern has evolved from multisensory research on reductions in systolic blood pressure and stress hormones; impact of sound and vibration on cognitive performance; and perceived improvements in mental health and tranquility as a result of non-visual sensory interactions with non-threatening nature.[2] Each sensory system varies in types and degrees of research to support it; here we provide just a taste.

Auditory. When compared to urban or office noise, nature sounds can accelerate physiological and psychological restoration up to 37% faster (Alvarsson et al., 2010), reduce cognitive fatigue and boost motivation (Jahncke et al., 2011), and assist with cognitive performance (e.g., Van Hedger et al., 2019). Listening to river sounds or seeing nature with river sounds can be more effective at restoring energy and motivation than listening to office noise or silence (Jahncke et al., 2011). Moreover, listening and viewing a river sounds simultaneously is shown to have a more positive effect than hearing without seeing river sounds. Ocean waves and vehicle traffic can have a very similar sound frequency. Researchers have observed that this sound may be processed in different portions of the brain depending on what is being viewed—ocean waves or vehicle traffic (e.g., Hunter et al., 2010). As a result, the same sound may be perceived as pleasurable when viewing waves, but unpleasurable when viewing traffic. These research examples suggest a strong connection between our visual and auditory sensory systems and psychological well-being.

Haptic and Tactile. Pet companionship and the act of petting and feeling the fur of domesticated animals is known to have profound calming effects; gardening and horticulture activities have shown to engender environmental stewardship among children, reduce self-reported fatigue while maintaining joint flexibility among adults (e.g., Yamane et al., 2004), and reduce perception of pain among people living with arthritis. Unlike the haptic experience of synthetic versions of nature, touching real plant life can induce relaxation through a change in cerebral blood flow rates (e.g., Koga & Iwasaki, 2013), touching real wood can induce a calming of the nervous system (Ikei, Song & Miyazaki, 2017; see also Pattern #9), and multisensory connections with water can enhance psychological and physiological responsiveness (e.g., Hunter et al., 2010; see also Pattern #5).

Olfactory. Our olfactory system processes scent directly in the brain, which can trigger very powerful memories. Traditional practices have long used plant oils to calm or energize people (e.g., Harada et al., 2018). Olfactory exposure to herbs and phytoncides (essential oils from trees) can have a positive effect on the healing process, human immune function, and cardio-respiratory response, respectively (Li et al., 2012; Kim et al., 2007; Grote et al., 2021).

Gustatory. Flavors and spices can connect people to place. While adults are often curious or fearful of edible plants and herbs, consider the familiar habit of infants and toddlers putting found objects in their mouths—they are seeking information.

Working with the Pattern

The objective of the Non-Visual Connection with Nature pattern is to provide an environment that uses sound, scent, touch, temperature, and sometimes even taste, to engage the individual in a manner that helps reduce stress and improve physical and mental health. Design considerations for establishing strong non-visual connections with nature:

- Design for non-visual connections that can be easily accessed and in ways that allow frequent engagement.
- Design for multisensory connections to maximize potential positive health impact. Non-visual connections enhance visual connections.
- Prioritize nature sounds over mechanical masking and urban sounds.
- Consider opportunities to integrate sensory experiences with architectural and mechanical solutions.

Non-visual connections with nature are experienced throughout the Alhambra in Granada, Spain. The integration of water and natural ventilation with the architecture is central to the multisensory experience. Solar heat penetrates at distinct locations, the whispering gallery resonates sounds of nature and people, and gardens of rosemary, myrtles, and other fragrant plants surround the premises. The extensive use of water fountains creates a microclimate – the space sounding and feeling cooler – while stone floors and handrails with water channels cool the feet and hands through thermal conductance.

Resources for digging deeper

- The Nature of Wood (Browning, Ryan & DeMarco, 2022)
- An Ear for Nature (Browning & Walker, 2018)
- *Thermal Delight In Architecture* (Lisa Heschong, 1979)
- *Creating Sensory Spaces* (Barbara Erwine, 2016)

Example Characteristics

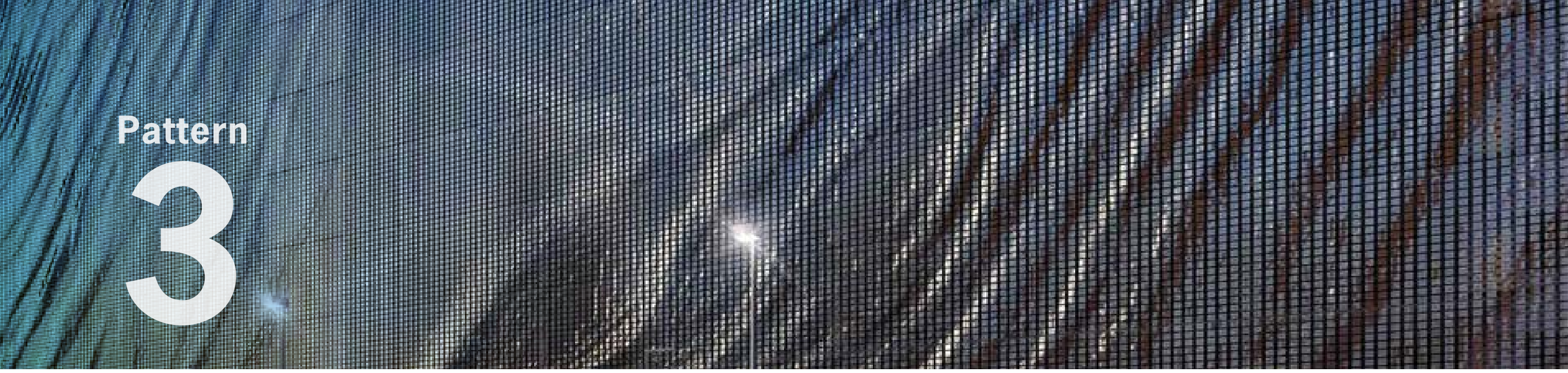
Naturally Occurring

- Fragrant herbs and flowers
- Songbirds
- Flowing water
- Weather (rain, wind, hail)
- Natural ventilation (operable windows, breezeways)
- Textured materials (stone, wood)
- Crackling fire/fireplace
- Sun patches
- Warm/cool surfaces

Simulated or Constructed

- Digital simulations of nature sounds
- Mechanically released natural plant oils
- Highly textured fabrics/ textiles with natural textures
- Audible and/or physically accessible water feature
- Music with fractal qualities
- Horticulture, edible plants
- Domesticated animals/pets
- Honeybee apiary

Above: Multisensory courtyard at The Alhambra (c.1238–1358). Image by Dax Fernstrom.



Pattern 3

Non-Rhythmic Sensory Stimuli

* *

Stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely.

Top: Kinetic membrane of the Brisbane Domestic Terminal Airport Carpark by Ned Kahn. Image © Daniel Clifford.

The Experience

A space with good Non-Rhythmic Sensory Stimuli feels as if one is momentarily privy to something special, something fresh, interesting, stimulating and energizing. It is a brief but welcome distraction.

Non-Rhythmic Sensory Stimuli differs from Non-Visual Connection with Nature in that it is most commonly experienced at a subconscious level through momentary exposure that is not typically sought out or anticipated; whereas, non-visual connections may be deliberate, planned, and more predictable.

Roots of the Pattern

The Non-Rhythmic Sensory Stimuli pattern has evolved from research on looking behavior (particularly periphery vision movement reflexes); eye lens focal relaxation patterns; heart rate, systolic blood pressure and sympathetic nervous system activity; and observed and quantified behavioral measures of attention and exploration.[3]

Studies of the human response to stochastic movement of objects in nature and momentary exposure to natural sounds and scents have shown to support physiological restoration. For instance, when sitting and staring at a computer screen or doing any task with a short visual focus, the eye's lens becomes rounded with the contracting of the eye muscles. When these muscles stay contracted for an extended period, i.e., more than 20 minutes at a time, fatigue can occur, manifesting as eye strain, headaches and physical discomfort. A periodic, yet brief visual or auditory distraction that causes one to look up (for >20 seconds) and to a distance (>20 feet) allows for short mental breaks during which (at >100 feet) the ocular muscles relax and the lenses flatten (Lewis, 2012; Vessel, 2012).

Working with the Pattern

The objective of the Non-Rhythmic Sensory Stimuli pattern is to encourage the use of natural sensory stimuli that unobtrusively attract attention, allowing individuals' capacity for focused tasks to be replenished from mental fatigue and physiological stressors. This can be achieved by designing for momentary exposure to the stochastic or unpredictable movement, particularly for periphery vision or the periodic experience of scents or sounds.

Researched benefits to...

PHYSIOLOGICAL: Restoration, Eye lens focal relaxation, Sympathetic nervous system activity, Heart rate, Systolic blood pressure

COGNITIVE: Attention, Exploration

When immersed in nature, we continually experience instances of non-rhythmic stimuli: birds chirping, leaves rustling, the faint scent of eucalyptus in the air. The built environment has evolved into a deliberately predictable realm. Even some highly manicured gardens and certainly interior vegetation lack the qualities needed to support non-rhythmic sensory stimuli.

Design considerations for establishing accessible and effective non-rhythmic stimuli:

- As a general guideline, sensory experiences should occur non-rhythmically but preferably not more than 20 minutes apart, for a duration of 20 seconds or more and, to induce eye fatigue restoration, from a distance of more than 100 feet.
- Many stimuli in nature are seasonal, so a strategy that is effective year-round, such as with multiple interventions that overlap with seasons, will help ensure that non-rhythmic sensory experiences can occur at any given time of the year.
- In some cases, the intervention may be similar to that of [P1] Visual or [P2] Non-Visual Connection with Nature; what's important here is the ephemeral and stochastic quality of the intervention.
- An intervention that leverages simulation of (rather than naturally occurring) natural stimuli will likely necessitate early collaboration with the mechanical engineer or facilities team.
- A non-rhythmic stimuli strategy can be interwoven with almost any landscape or horticulture plan. For instance, selecting plant species for window boxes that will attract bees, butterflies and other pollinators may be a more practical application for some projects than maintaining a honeybee apiary or butterfly sanctuary.
- Humans perceive movement in the peripheral view much quicker than straight ahead. The brain also processes the movement of living things in a different place than it does of mechanical objects (Beauchamp et al., 2003), whereby natural movement is generally perceived as positive, and mechanical movement as neutral or even negative. As a result, the repeating rhythmic motion of a pendulum will only hold one's attention briefly, the constant repetitive ticking of a clock may come to be ignored over time, and an ever-present scent may lose its mystique with long-term exposure; whereas, the stochastic movement of a butterfly will capture one's attention each time for recurring physiological benefits.

The Dockside Green community on Vancouver Island in British Columbia, Canada, is a great example of non-rhythmic stimuli. The implementation of habitat restoration and rainwater management has led to ephemeral experiences of swaying grasses, falling water and the buzz of passing insects and animals that are visible from walkways, porches, and windows around the community.

Example Characteristics

Naturally Occurring

- Cloud movement
- Breezes
- Plant life rustling
- Water babbling
- Insect and animal movement
- Birds chirping
- Fragrant flowers, trees and herbs

Simulated or Constructed

- Billowy fabric or screen materials that move or glisten with light or breezes
- Surface reflections of water
- Shadows or dappled light that change with movement or time
- Nature sounds broadcasted at unpredictable intervals
- Mechanically released plant oils

Above: The diverse vegetation surrounding residences at Dockside Green on Vancouver Island in British Columbia, ensure stochastic movement from breezes, wildlife and water visible throughout the community. Photo courtesy Bill Browning.

Thermal & Airflow Variability

* *

Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.

Top: Cloisters at San Juan de Los Reyes, Toledo, Spain. Image © Ben Leto/Flickr.

The Experience

A space with good Thermal & Airflow Variability feels refreshing, active, alive, invigorating and comfortable. The space provides a feeling of both flexibility and a sense of control.

Roots of the Pattern

The Thermal & Airflow Variability pattern has evolved from research measuring the effects of natural ventilation, its resulting thermal variability, and worker comfort, well-being and productivity; physiology and perception of temporal and spatial pleasure (alliesthesia); the impact of nature in motion on concentration; and, generally speaking, a growing discontent with the conventional approach to thermal design, which focuses on achieving a narrow target area of temperature, humidity and air flow while minimizing variability.[4a]

Research shows that people like moderate levels of sensory variability in the environment, including variation in light, sound and temperature, and that an environment devoid of sensory stimulation and variability can lead to boredom and passivity (e.g., Heerwagen, 2006).[4b] Early studies in alliesthesia indicate that pleasant thermal sensations are better perceived when one's initial body state is warm or cold, not neutral (e.g., Mower, 1976), which corroborates more recent studies reporting that a temporary over-cooling of a small portion of the body when hot, or over-heating when cold, even without impacting the body's core temperature, is perceived as highly comfortable (Arens et al., 2006).

According to Attention Restoration Theory, elements of "soft fascination" such as light breezes or other natural movements can improve concentration (Heerwagen & Gregory, 2008; S. Kaplan, 1995). Other research indicates that a variety of thermal conditions within a classroom can lead to better student performance (Elzeyadi, 2012); and that changes in ventilation velocity can have a positive impact on comfort, with no negative impact on cognitive function, while also offering the possibility of some increase in the ability to access short term memory (Wigö, 2005).

Researched benefits to…

PSYCHOLOGICAL: Comfort, Perceived temporal and spatial pleasure, Boredom, Passivity, Well-being,

COGNITIVE: Concentration, Workplace Productivity, Student performance, Short term memory

Working with the Pattern

The objective of the Thermal & Airflow Variability pattern is to provide an environment that allows users to experience the sensory elements of airflow variability and thermal variability. The intent is also for the user/occupant to be able to control thermal conditions, either by using individual controls, or by having access to variable conditions within a space or series of spaces.

Conventional thermal design targets a narrow range of temperature, humidity and airflow, while minimizing variability – these conditions within the "ASHRAE comfort envelope", while perhaps a good baseline, present a scenario that's almost never experienced in nature. Providing combinations of ambient and surface temperatures, humidity, and airflow similar to those experienced outdoors, while also providing some form of personal control over those conditions, will help surpass the widely-accepted but arguably inadequate 80% satisfaction target under ASHRAE.

Since thermal comfort is inherently subjective, and strongly varies between people, it is important to give a degree of control to individuals. When an individual experiences thermal discomfort, they will likely take action to adapt (e.g., put on a sweater; open/close a window; move to a different seat; submit a complaint). These adaptive actions may simply be in response to dynamic changes in personal preference.

Design considerations:

- Providing variable conductance materials, seating options with differing levels of solar heat gain or proximity to operable windows could improve the overall satisfaction of a space.
- Incorporating airflow and thermal conditions into strategy discussions for mechanical ventilation and/or fenestration will help achieve distributed variability over space and time.
- Consider solutions that subsequently broaden the occupants' perception of thermal comfort, as it may also increase the range of acceptable temperatures and help reduce energy demands for air conditioning and heating.
- Coordination of design strategies among project team disciplines (e.g., architect, lighting designer, MEP engineers) as early as the schematic design process is critical for achieving this experiential outcome.

The passive design of Singapore's Khoo Teck Puat Hospital, designed by RMJM Architects and CPG Consultants, draws fresh air in from the exterior courtyards. The cool air helps maintain thermal comfort, while patients also have operable windows in their rooms, allowing for greater personal control. Elevated, exterior walkways also provide access to breezes, shade and solar heat.

Resources for digging deeper

- Designing for Experiential Delight (Gail Brager, 2019)

Example Characteristics

Naturally Occurring

- Solar heat gain
- Shadow and shade
- Radiant surface materials
- Space/place orientation
- Vegetation with seasonal densification

Simulated or Constructed

- HVAC delivery strategy
- Systems controls
- Window glazing and window treatment
- Window operability and cross ventilation

Above: The Khoo Teck Puat Hospital in Singapore, by RMJM Architects and CPG Consultants, incorporates façade solutions that allow fresh air and sunlight to increase thermal comfort. Image © Jui-Yong Sim/Flickr.

Pattern 5

Presence of Water

* *

A condition that enhances the experience of a place through the seeing, hearing or touching of water.

Top: Rice University, TX. Image courtesy of archdaily.com.

The Experience

A space with a good Presence of Water condition feels compelling and captivating. Fluidity, sound, lighting, proximity and accessibility each contribute to whether a space is stimulating, calming, or both.

Roots of the Pattern

The Presence of Water pattern has evolved from research on visual preference for and positive emotional responses to environments containing water elements; reduced stress, increased feelings of tranquility, and lower heart rate and blood pressure from exposure to water features; improved concentration and memory restoration induced by complex, naturally fluctuating visual stimuli; and enhanced perception and psychological and physiological responsiveness when multiple senses are stimulated simultaneously.[5]

Visual preference research indicates that a preferred view contains bodies of clean (i.e., unpolluted) water (Heerwagen & Orians, 1993). Research has also shown that landscapes with water elicit a higher restorative response and generally have a greater preference among populations in comparison to landscapes without water. In addition, natural scenes without water and urban scenes with water elements follow with primarily equal benefits (Jahncke et al., 2011; Karmanov & Hamel, 2008; White, et al., 2010).

Research on response to activities conducted in green spaces has shown that the presence of water prompts greater improvements in both self-esteem and mood than activities conducted in green environments without the presence of water (Barton & Pretty, 2010). Auditory access and perceived or potential tactile access to water also reportedly reduces stress (Alvarsson et al., 2010; Pheasant et al., 2010). Perhaps most critical is that repeated experiences of water do not significantly diminish our level of interest over time (Biederman & Vessel, 2006).

Researched benefits to...

PHYSIOLOGICAL: Stress, Heart rate, Blood pressure, Responsiveness

PSYCHOLOGICAL: Emotion, Feelings of tranquility, View preference

COGNITIVE: Concentration, Memory, Perception

Working with the Pattern

The objective of the Presence of Water pattern is to capitalize on the multi-sensory attributes of water to enhance the experience of a place in a manner that is soothing, prompts contemplation, enhances mood, and provides restoration from cognitive fatigue.

As repeated experiences of water do not significantly diminish interest over time, one small, well-designed water feature may be adequate. Taking advantage of the sounds created by small-scale running water, and our capacity to touch it, will amplify the desired health response with a multi-sensory experience. Vistas to large bodies of water or physical access to natural or designed water bodies can also have the health response so long as they are perceived as 'clean' or unpolluted. Images of nature that include aquatic elements are more likely to help reduce blood pressure and heart rate than similar imagery without aquatic elements.

Design considerations for optimizing the impacts of a presence of water:

- Prioritize a multi-sensory water experience to achieve the most beneficial outcome.
- Prioritize naturally fluctuating water movement over predictable movement or stagnancy.
- High volume, high turbulence water features could create discomfort, impact humidity levels or decrease acoustic quality, so proximity may influence appropriateness.
- Water features can be water and energy intensive and as such should be used sparingly, particularly in climates with little access to water. Shading the water, using high albedo surfaces, and minimizing the exposed water surface area will minimize water loss through evaporation, and possibly contribute to the biophilic experience.

The Robert and Arlene Kogod Courtyard at the Smithsonian American Art Museum in Washington, DC, is a great example of Presence of Water with its physically expansive water feature, designed by Gustafson Guthrie Nichol Ltd., doubling as an event space. The former outdoor space has been enclosed with an undulating canopy design by Foster + Partners, bearing resemblance to water or clouds. On several portions of the gently sloping floors are slits from which a sheet of water emerges, it flows across the textured stone and then disappears into a series of slots toward the center of the courtyard. The thin sheet of water reflects light and weather conditions from above and invites passersby to touch. During events the system is drained and seamlessly becomes part of the floor plane.

Example Characteristics

Naturally Occurring

- River, stream, ocean, pond, wetland
- Visual access to rainfall and flows
- Seasonal arroyos

Simulated or Constructed

- Water wall
- Constructed water fall
- Aquarium
- Fountain
- Constructed stream
- Reflections of water (real or simulated) on another surface
- Imagery with water in the composition

Above: The Robert and Arlene Kogod Courtyard in the Smithsonian American Art Museum, Washington, DC, by Foster + Partners and landscape designer Kathryn Gustafson of Seattle–based Gustafson Guthrie Nichol Ltd. has seamless water sheets running across the floor, reflecting weather and lighting conditions. Image © Tim Evanson/Flickr.

Pattern

6

Dynamic & Diffuse Light

*
* *

Varying intensities of light and shadow that change over time to create conditions that occur in nature.

Top: Skylight at Portland PDX International Airport terminal, designed by ZGF Architects. Image courtesy Catie Ryan.

Researched benefits to...

PHYSIOLOGICAL: Circadian system health, Hormone balance, Dental health, Sleep quality

PSYCHOLOGICAL: Perceived well-being, Mood, Depression

COGNITIVE: Performance, Productivity

The Experience

A space with a good Dynamic & Diffuse Light condition conveys expressions of time and movement to evoke feelings of drama and intrigue, buffered with a sense of calm.

Roots of the Pattern

Lighting design has long been used to set the mood for a space, and different lighting conditions elicit differing psychological responses. The impact of daylight on performance, mood and well-being has been studied for many years, in a variety of environments, and as a complex field of science and design, light has been extensively studied and written about.

Early research revealed that productivity is higher in well daylit work places, sales are higher in daylit stores, and children perform better in daylit classrooms. Quality daylighting is also noted to induce more positive moods, as well as significantly less dental decay among students attending schools with quality daylight than students attending schools with average light conditions (e.g., Nicklas & Bailey, 1996).

Dynamic & Diffuse Light has evolved as a pattern from this science as well as from contemporary research that has focused more heavily on illuminance fluctuation and visual comfort, human factors and perception of light, and impacts of light on the circadian system functioning.[6] The human body responds to the transition of color over the course of the day. The response is apparent in body temperature, heart rate, and circadian functioning. Higher content of blue light (similar to skylight) produces serotonin; whereas, an absence of blue light (which occurs at night) produces melatonin. The balance of serotonin and melatonin can be linked to sleep quality, mood, alertness, depression, breast cancer, and other health conditions (e.g., Kandel et al., 2013).

Working with the Pattern

The objective of the Dynamic & Diffuse Light pattern is twofold: to provide users with lighting options that stimulate the eye and hold attention in a manner that engenders a positive psychological or physiological response, and to help maintain circadian system functioning. The goal should not be to create uniform distribution of light through a (boring) space, nor should there be extreme contrasts (leading to glare discomfort).

The human eye and the processing of light and images within the brain are adaptable over a broad range of conditions, though there are limitations. Adjoining sources or surfaces with a high brightness or luminance ratio (e.g., ≥40:1) may cause undesireable glare in the workplace, or a dramatic and moving experience in a spiritual space. Solutions will naturally depend on the program and desired experience.

Diffuse lighting on vertical and ceiling surfaces provides a calm backdrop to the viewshed. Accent lighting can add layers of depth and interest, while task or personalized lighting can provide localized flexibility in intensity and direction. Coupled with light and shadows that change with the weather and time of day, these layers help create a pleasing and dynamic environment.

Just as variations in lighted surfaces are important for interpreting surfaces, focusing on a task, and safe navigation, circadian lighting is important for supporting biological health. Leveraging opportunities for illuminance fluctuation, light distribution, and light color variability that stimulate the human eye without causing discomfort will improve the quality of the user experience.

Design considerations for establishing a balance between dynamic and diffused lighting conditions:

- Dynamic lighting conditions that help transition between indoor and outdoor spaces.
- Drastically dynamic lighting conditions, such as with sustained movement, changing colors, direct sunlight penetration and high contrasts, may be appropriate for optional or interstitial spaces, but not for spaces where directed attention is needed.
- Circadian lighting will be especially critical in non-daylit spaces occupied for extended periods of time (i.e., ≥4 hours).
- The International Well Building Standard To support circadian health by setting a minimum threshold for daytime light intensity using Melanopic Light Intensity.

An example of a Dynamic & Diffuse Light condition is at the Yale Center for British Art, designed by Louis Kahn. Despite the building's stark exterior, the diversity of interior spaces and differing orientations of windows, clerestories, skylights and a large central atrium allows for light to penetrate at variable levels of diffusion to create an enhanced visitor experience, while upholding indoor environmental conditions necessary for displaying fine art.

Resources for digging deeper

- *Visual Delight in Architecture: Daylight, Vision and View* (Lisa Heschong, 2021)
- Circadian Lighting Design (International WELL Building Institute, 2020)

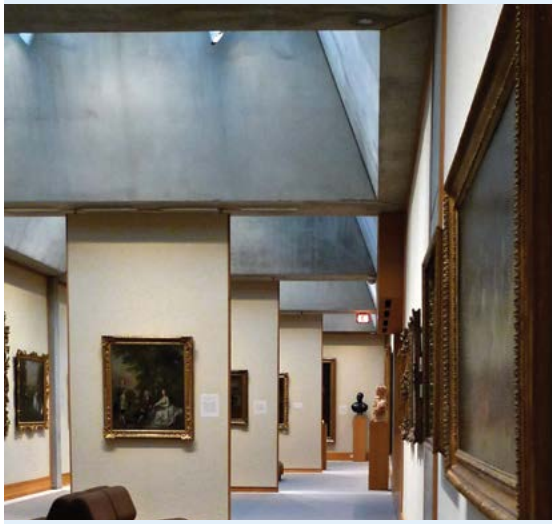
Example Characteristics

Naturally Occurring

- Daylight from multiple angles
- Direct sunlight
- Diurnal and seasonal light
- Firelight
- Moonlight and star light
- Bioluminescence

Simulated or Constructed

- Multiple low glare electric light sources
- Illuminance
- Light distribution
- Ambient diffuse lighting on walls and ceiling
- Day light preserving window treatments
- Task and personal lighting
- Accent lighting
- Personal user dimming controls
- Circadian color reference (color tuning electric light to mimic diurnal patterns, and minimize blue light at night)



Above: The Yale Center for British Art in New Haven, Connecticut, USA. Designed by Louis Kahn. Image © K. Kendall/Flickr.

Pattern 7

Connection with Natural Systems

The awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.

Top: Tanner Springs in Portland, Oregon, as an example of biocentric destination creation that connects people to the ecology and climate of the place. Atelier Dreiseitl, architect. Image courtesy of GreenWorkSpc.

Researched benefits to...

PSYCHOLOGICAL: Perceptual shift, Connection to place, Stewardship

The Experience

A space with a good Connection with Natural Systems evokes a relationship to a greater whole, making one aware of seasonality and the cycles of life. The experience may be relaxing, nostalgic, profound, and either anticipated or enlightening.

Roots of the Pattern

There is limited scientific documentation of the health impacts associated with access to natural systems; however, much like Presence of Water (Pattern #5), this pattern is suspected to enhance positive health responses. In *Biophilic Design* (Kellert et al., 2008), Kellert frames this as "Natural Patterns and Processes", whereby seeing and understanding the processes of nature can create a perceptual shift in what's being seen and experienced. This pattern has a strong temporal element, which can be expressed culturally, as in the Japanese love of the ephemerality of cherry blossoms. The notion that humans can have authentic connections with natural systems is perhaps antecedent both to having a biocentric outlook and to employing biocentric design.

Working with the Pattern

The objective of the Connection with Natural Systems pattern is to heighten both awareness of natural properties and hopefully environmental stewardship of the ecosystems within which those properties prevail. The strategy for working with the pattern may be as simple as identifying key content in a view to nature (e.g., deciduous trees in the back yard or blossoming orchids on the window sill).

Alternatively, a more complex integration of systems may be approapriate, such as by making evident the relationship between building occupant behavior and rainwater infrastructure (e.g., raingardens, bioswales, storm sewers, arroyos) capacity by regulating domestic activities (e.g., showering, laundry) during rain events. In either case, the temporal component is usually the key factor in pattern recognition and the triggering of a deeper awareness of a functioning ecosystem.

Design considerations and opportunities that may help create quality connections with natural systems:

- Integration of rainwater capture and treatment into the landscape design that responds to rain events.
- Consider the level of awareness and "connection" desired.
  - In some cases, providing visual access to existing natural systems will be the easiest and most cost–effective approach.
  - In other cases, the incorporation of responsive design tactics (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.
- Design interactive opportunities, especially for children, patients, and the elderly (e.g., integrative educational curricula; horticulture programs, community gardens; seasonal cooking/diet).

Outside the New York penthouse office of COOKFOX Architects, sits a 3,000 square foot extensive green roof that changes color and vibrancy from season to season. Witnessing a hawk killing a small bird shifted employee perception of their green roof as an ecosystem and not just a decorative garden. This perception was reinforced when employees noticed changes in bee colony behavior during times of extreme heat and humidity, when the honeybee apiary was invaded by robber bees, and again when the summer honey harvest looked and tasted different than the autumn harvest.

Resources for digging deeper

- *The Grand Biocentric Design* (Lanza, Pavsic & Berman, 2021)

Example Characteristics

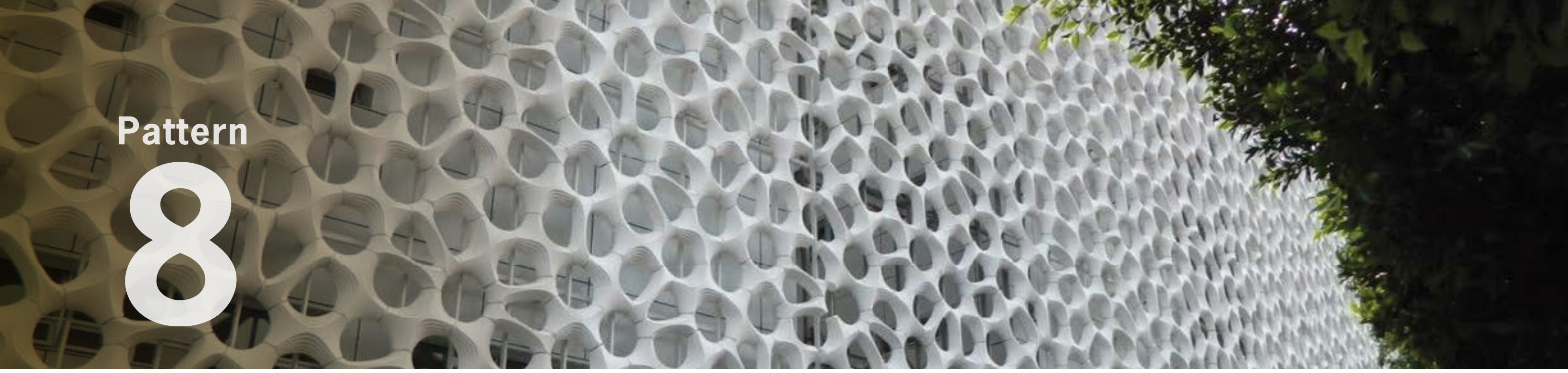
Naturally Occurring

- Climate and weather patterns (rain, hail, snow; wind, clouds, fog; thunder, lightning)
- Hydrology (precipitation, surface water flows and resources; flooding, drought; seasonal arroyos)
- Geology (visible fault lines and fossils; erosion, shifting dunes)
- Animal behaviors (predation, feeding, foraging, mating, habitation)
- Pollination, growth, aging and decomposition (insects, flowering, plants)
- Diurnal patterns (light color and intensity; shadow casting; plant receptivity; animal behavior; tidal changes)
- Night sky (stars, the Milky Way) and cycles (moon stages, eclipses, astronomical events)
- Seasonal patterns (freeze-thaw; light intensity and color; plant cycles; animal migration; ambient scents)

Simulated or Constructed

- Simulated daylighting systems that transition with diurnal cycles
- Wildlife habitats (e.g., birdhouse, honeybee apiary; hedges, flowering vegetation)
- Exposed water infrastructure
- Step wells for seasonal rainwater storage and social convergence
- Natural patina (leather, stone, copper, bronze, wood)

Left: The greenroof at 641 6th Ave in New York dramatically changes in appearance through the year, connecting occupants with the seasons and local ecosystem activity. Images courtesy of Bill Browning.



Pattern 8

Biomorphic Forms & Patterns

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Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature.

Top: Façade of Manuel Gea González Hospital in Mexico City. Image © misia-nov-dom.

The Experience

A space with good Biomorphic Forms & Patterns feels interesting and comfortable, possibly captivating, contemplative or even absorptive.

Roots of the Pattern

Biomorphic Forms & Patterns has evolved from research on view preferences (Joye, 2007), reduced stress due to induced shift in focus, and enhanced concentration. We have a visual preference for organic and biomorphic forms but the science behind why this is the case is not yet formulated. While our brain knows that biomorphic forms and patterns are not living things, we may describe them as symbolic representations of life (Vessel, 2012).

Right angles and straight lines don't exist in nature. The Golden Angle, which measures approximately 137.5 degrees, is the angle between successive florets in some flowers, while curves and angles of 120 degrees are frequently exhibited in other elements of nature (e.g., Thompson, 1917).

The Fibonacci series (0, 1, 1, 2, 3, 5, 8, 13, 21, 34...) is a numeric sequence that occurs in many living things, plants especially. Phyllotaxy, or the spacing of plant leaves, branches and flower petals (so that new growth doesn't block the sun or rain from older growth) often follows in the Fibonacci series. Related to the Fibonacci series is the Golden Mean (or Golden Section), a ratio of 1:1.618 that surfaces time and again among living forms that grow and unfold in steps or rotations, such as with the arrangement of seeds in sunflowers or the spiral of seashells.

Biomorphic forms and patterns have been artistically expressed for millennia, from adorning ancient temples to more modern examples like Hotel Tassel in Brussels (Victor Horta, 1893) and the structures of Gare do Oriente in Lisbon (Santiago Calatrava, 1998). More intriguing still is the architectural expression of mathematical proportions or arrangements that occur in nature, the meaning of which has been fodder for philosophical prose since Aristotle and Euclid. Many cultures have used these mathematical relationships in the construction of buildings and sacred spaces. The Egyptian Pyramids, the Parthenon (447–438 BC), Notre Dame in Paris (beginning in 1163), the Taj Mahal in India (1632–1653), Mexico City

Researched benefits to...

PHYSIOLOGICAL: Stress

PSYCHOLOGICAL: Visual preference

COGNITIVE: Concentration

Metropolitan Cathedral (c.1667–1813), the CN Tower in Toronto (1976), and the Eden Project Education Centre in Cornwall, England (2000) are all alleged to exhibit the Golden Mean.

Working with the Pattern

The objective of Biomorphic Forms & Patterns is to provide representational design elements within the built environment that allow users to make connections to nature. The intent is to use biomorphic forms and patterns in a way that creates a more visually preferred environment that enhances cognitive performance while helping reduce stress.

Humans have been decorating living spaces with representations of nature since time immemorial, and architects have long created spaces using elements inspired by trees, bones, wings and seashells. Many classic building ornaments are derived from natural forms, and countless fabric patterns are based on leaves, flowers, and animal skins. Contemporary architecture and design have introduced more organic building forms with softer edges or even biomimetic qualities.

There are essentially two approaches to applying Biomorphic Forms & Patterns, as either a cosmetic decorative component of a larger design, or as integral to the structural or functional design. Both approaches can be utilized in tandem to enhance the biophilic experience.

Design considerations that may help create a quality biomorphic condition:

- Apply on 2 or 3 planes or dimensions (e.g., floor plane and wall; furniture windows and soffits) for greater diversity and frequency of exposure.
- Avoid the overuse of forms and patterns that may lead to visual toxicity.
- More comprehensive interventions will be more cost effective when they are introduced early in the design process.

The Art Nouveau Hotel Tassel in Brussels (Victor Horta, architect, 1893) is a favorite example of Biomorphic Forms & Patterns. The interior space in particular is rife with natural analogues, with graphic vine-like tendrils painted on the wall and designed into the banisters and railings, floor mosaics, window details, furniture, and columns. The curvaceous tiered steps seem to make distant reference to shells or flower petals.

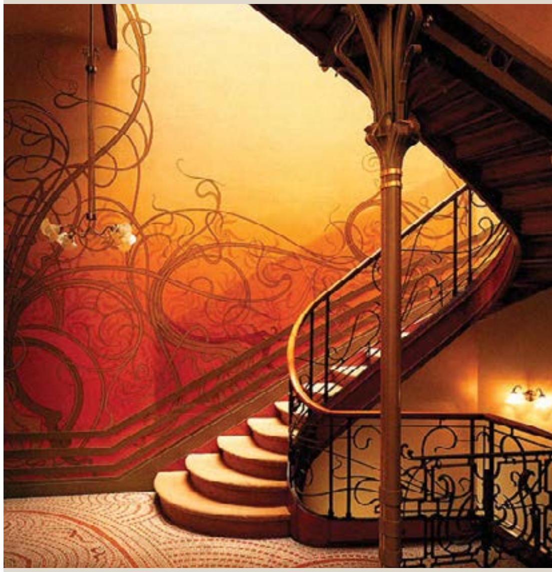
Examples

Decor

- Fabrics, carpet, wallpaper designs based on Fibonacci series or Golden Mean
- Window details: trim, moldings, glass color, texture, mullion design, window reveal detail
- Installations and free-standing sculptures
- Furniture details
- Woodwork, masonry
- Wall decal, paint style/ texture

Form/Function

- Structural columns
- Building form
- Acoustic wall/ceiling panels
- Railing, banister, fence, gate
- Furniture form
- Windows: frit, light shelf, fins
- Pathway and hallway form



Above: Curvaceous stairs, mosaics, railings, light fixtures, and window details are quintessential characteristics of the Hotel Tassel in Brussels, by Victor Horta. Image © Eloise Moorhead.

Material Connection with Nature

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* *

Material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place.

Top: Bamboo pavilion by WOHA architects. Image courtesy of WOHA architects.

Researched benefits to...

PHYSIOLOGICAL: Blood pressure, Heart rate variability, Calming effect, Parasympathetic (rest) activity, Cortisol levels

PSYCHOLOGICAL: Preference

COGNITIVE: Creativity, Performance

The Experience

A space with a good Material Connection with Nature feels rich, warm and authentic, and sometimes stimulating to the touch.

Roots of the Pattern

The Material Connection with Nature pattern has evolved from early studies on the impacts of exposure to natural materials and colors on creativity and cognitive performance. Little new research has emerged to further understand the impacts of a natural color palette, particularly the color green, on creativity (e.g., Lichtenfeld et al., 2012). While humans may be able to distinguish more variations of green than of any other color (Painter, 2014), which variation(s) of green most influence creativity or other mind-body responses is still not well understood.

Consideration for wood ratios relative to intended impact—just how calming a space is meant to be (e.g., Tsunetsugu, Miyazaki & Sato, 2007)—has been supplemented with research on matters of human perception and natural materials, textures, and fractal characteristics or, more specifically, material grain.

While a material connection can be multisensory, the material itself is processed by the brain based on surface characteristics, such as texture and color, rather than form and shape (Biederman, 1987). The positive visual experience of wood, for instance, is largely invested in grain pattern and surface color, with attention to or preference for unfinished, imperfect, or bare wood (Høibø & Nyrud, 2010; Nakamura & Kondo, 2008). Whereas haptic experiences of wood can help lower blood pressure (Morikawa, Miyazaki, & Kobayashi, 1998; Sakuragawa, Kaneko & Miyazaki, 2008) and increase activity of the parasympathetic (rest and calming) portion of the nervous system (Ikei, Song & Miyazaki, 2017) in ways that cannot be achieved through tactile experiences with heavily processed materials.

One possible explanation for our biophilic response to natural materials is that the brain makes associations. For instance, the brain subconsciously links wood to trees and trees to life and nature. Associative processing is what is believed to trigger a biophilic response (Vessel et al., 2018; Vessel, 2012; Rametsteiner et al., 2007). Another explanation is that wood grain as a series of collinear, nested contours—pattern conditions that occur frequently in nature and for which our brains may be predisposed to easily decipher (i.e. fractal fluency) resulting in stress reduction (Albright, 2002).[9]

Working with the Pattern

The objective of the Material Connection with Nature pattern is to explore the characteristics of natural materials optimal for engendering positive cognitive or physiological responses. In some cases, there may be several layers of information in materials that enhance the connection, such as learned knowledge about the material, familiar textures, or nested fractals that occur within a stone or wood grain pattern.

Natural materials can be decorative or functional, and are typically processed or extensively altered (e.g., wood plank, granite countertop) from their original 'natural' state, and while they may be extracted from nature, they are only analogous of the items in their 'natural' state.

Design considerations that may help create a quality material connection:

- Don't hide the grain. As the brain is more receptive to surface characteristics than form and shape, choose a finish that enhances the grain pattern—thick coats of paint or lacquer, or heavy polishing can hide the characteristics that distinguish it as being natural.
- Making natural materials readily visible. Quantities of a (natural) material should be specified based on intended function of the space (e.g., to restore versus stimulate), though a degree of variability of materials and applications is recommended over high ratios of any one material.
- Prioritize real materials over synthetic variations. Human brain receptors can tell the difference between real and synthetic—which could make the difference between engendering intrigue or disappointment.
- Consider the haptic and olfactory experiences of a material or product to enhance the overall material connection.

The lobby of the Bank of America Tower at One Bryant Park in New York (COOKFOX Architects, 2009) is a good example of a diverse application of Material Connections with Nature. One enters the glass skyscraper by grasping a thin wooden door handle. The interior lobby walls are clad with Jerusalem stone—tiles with the highest fossil content were intentionally placed at the corner where they would be most encountered and touched by passersby. Patinaed from years of touch, leather paneling in the elevator lobby is warm in color, providing a calming sense of arrival as people await their ride.

Resources for digging deeper

- The Nature of Wood, An exploration of the science on biophilic responses to wood (Browning, Ryan & DeMarco, 2022)

Examples

Decor

- Accent details (natural wood grains; leather; stone, fossil textures; bamboo, rattan, dried grasses, cork)
- Interior surfaces (veneer, countertops)
- Woodwork, stonework
- Natural color palette, particularly greens

Form/Function

- Wall construction (wood, stone)
- Structural systems (heavy timber beams)
- Façade material
- Furniture form
- Footpaths, bridges

Above: Leather clad elevator lobby of the Bank of America Tower in New York by COOKFOX Architects visually warms the space. Image © Bilyana Dimitrova / Photography by Bilyana Dimitrova.

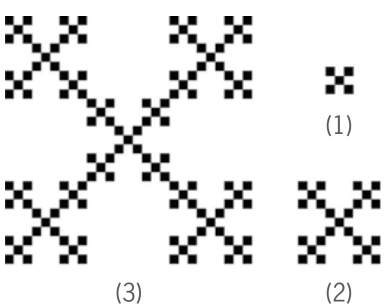
Pattern
10

Complexity & Order

* *

Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.

Top: Summer Palace, Beijing, China. Image courtesy of Bill Browning.



A square (■) with a scaling factor of 3 is more impactful than to a factor of 2.

Researched benefits to...

PHYSIOLOGICAL: Stress

PSYCHOLOGICAL: Perceived stress, Subjective mood, Preference

COGNITIVE: Capacity for processing information (in visual field), Relaxation, Navigation, Learning

The Experience

A space with good Complexity & Order feels engaging and information-rich, as an intriguing balance between boring and overwhelming.

Roots of the Pattern

The Complexity & Order pattern has evolved from research on fractal geometries and preferred views; the perceptual and physiological responses to the complexity of fractals in nature, art and architecture; and the predictability of the occurrence of design flows and patterns in nature. [P10].

Research has repeatedly correlated fractal geometries in nature with those in art and architecture (e.g., Joye, 2007; Taylor, 2006). In the built environment, we consider both exact and statistical fractals. Exact fractals, being exact repeating nested patterns (e.g., Koch Curve, Vicsek Curve, Mandelbrot set), don't often occur in nature. Statistical fractals, fractals with variability in its repetition, occur frequently in nature (e.g., snowflakes, beach waves, fern fronds, crackling flames, dappled sunlight under trees). Statistical fractals are so common in nature that, when seen in a human-designed object, the brain processes the image so easily that a stress reduction response results; this inherent literacy is referred to as "fractal fluency" (Hägerhäll et al., 2015; Taylor et al., 2018).

Nested complexity. Nested fractal designs, whether exact or statistical, that are expressed as a third iteration of the base design (i.e., with scaling factor of 3, see illustration) are more likely to achieve a level of complexity that conveys a sense of order and intrigue, and reduces stress (Salingaros, 2012), a quality lost in much of modern architecture, which tends to limit complexity to the second iteration, and consequently results in an arguably dull and inadequately nurturing form that fails to stimulate the mind or engender physiological stress reduction.

Fractal dimensions. The ratio of geometric complexity of a fractal, particularly with statistical fractal, is expressed as the fractal dimension. The range of preferred fractal dimensions is potentially quite broad (D=1.3-1.8) depending on the application (Salingaros, 2012). A lower range fractal dimension may be preferred in indoor settings while a higher range may be preferred outdoors (Abboushi et al., 2019). High-dimensional (e.g., D=1.9) fractal artwork has been shown to induce stress (Hägerhäll et al., 2008; Taylor, 2006).

Working with the Pattern

The objective of the Complexity & Order pattern is to provide symmetries and fractal geometries, configured with a coherent spatial hierarchy, to create a visually nourishing environment that engenders a positive psychological or cognitive response (Salingaros, 2012). Fractals can exist at any scale, from desktop trinkets and textile patterns to frit and façade design, to a building floor plan, city grid or regional transport infrastructure.

A familiar challenge in the built environment is in identifying the balance between an information rich environment that is interesting and restorative, and one with an information surplus that is overwhelming, stressful or even dizzying. Identifying specific fractal dimensions in existing conditions or designs can also be a challenge and usually requires close study, such as when creating a new product or design pattern.

These design considerations may help create a quality Complexity & Order condition:

- Prioritize artwork and material selection, architectural expressions, and landscape and master planning schemes based on fractal geometries and hierarchies.
- Fractal structures with iterations of three will be more impactful than a design limited to two iterations.
- Computer technology using the algorithms of mathematical and geometric functions can produce fractal designs with ease. If a digital approach is being taken, consider assigning geometries with a mid-range dimensional ratio (broadly speaking, D=1.3–1.75).
- Find balance. Over-use of and/or extended exposure to high-fractal dimensions could instill discomfort or even fear, countering the intended response: to nourish and reduce stress, while avoidance or under-utilization of fractals could result in complete predictability and disinterest.
- Consider the impact of a new building or landscape design on the fractal quality of the existing landscape or urban skyline so as not to diminish existing benefits.

The design team at Marriott International crafted an overhead perforated panel for Westin guest room entryways that deliberately splashes fractal light patterns on the walls—much like the dappled light in a forest. The lighting fixture design is a deliberate effort to help lower stress the moment a guest opens the door.

Resources for digging deeper

- Fractal Fluency in the Built Environment (Fractals Research and 13&9 Design, 2021)
- Working with Fractals (Rita Trombin White, 2020)

Examples

Decor

- Wallpaper and carpet design
- Material texture and contour
- Window details: trim, moldings, glass color, texture, mullion design, window reveal detail
- Plant selection variety and placement
- Complex plant oil fragrances
- Auditory stimuli

Form/Function

- Exposed structure/exoskeleton
- Exposed mechanical systems
- Façade materials
- Façade, spandrel and window hierarchy
- Building skyline
- Floor plan, landscape plan, urban grid
- Pedestrian and traffic flows
- Resource flows

Above: Dappled light in the guest room foyer of a Westin prototype room. Image courtesy Marriott International.

Pattern 11

Prospect

An unimpeded view over a distance for surveillance and planning.

Top: The Stockholm City Hall's inner courtyard frames views to the north shore of Riddarfjärden (bay), a popular spot for wedding photos. Designed by architect Ragnar Östberg and constructed 1911–1923. Image © Catie Ryan.

The Experience

A space with a good Prospect condition feels open and freeing, yet imparts a sense of safety and control, particularly when alone or in unfamiliar environments.

Roots of the Pattern

The Prospect pattern has evolved from research on visual preference and spatial habitat responses, as well as cultural anthropology, evolutionary psychology and architectural analysis. Health benefits are suggested to include reduction in stress, boredom, irritation, fatigue and perceived vulnerability, as well as improved comfort.[11]

In evolutionary psychology terms, we should prefer habitats that are similar to the African savannas on which we evolved as a species. This becomes clear in visual preference research starting with Jay Appleton's *Experience of Landscape* in 1977, where he asked why certain views from the same vantage point are preferred over others. Kellert and Wilson (1993) argue that our view preferences, and possibly our aesthetic preferences, have roots in referential points that benefit our survival. For example, flowers are indicators of healthy plant growth, and to signal the availability of resources in the future (Orians & Heerwagen, 1992). The savanna, with its open terrain and copses of shade trees, becomes more favorable when combined with water, an understory of flowers and forbs, calm grazing animals and evidence of human habitation. That we should be genetically predisposed to prefer this scene is posited by the Savanna Hypothesis (Heerwagen & Orians, 1986; Orians & Heerwagen, 1992).

Distant prospect (>100 feet, >30 meters) is preferred over shorter focal lengths (<20 feet, 6 meter) because it provides a greater sense of awareness and comfort (Herzog & Bryce, 2007), reducing one's stress responses, particularly when alone or in unfamiliar environments (Petherick, 2000). Good Prospect is extensive and information rich, with a savanna–like view.

Working with the Pattern

The objective of the Prospect pattern is to provide users with a condition suitable for visually surveying and contemplating the surrounding environment for both opportunity and hazard. In landscapes, Prospect is characterized as the view from an elevated position or across an expanse.

Researched benefits to...

PHYSIOLOGICAL: Stress, Fatigue, Comfort

PSYCHOLOGICAL: Boredom, Irritation

COGNITIVE: Decision making

While an elevated position can enhance (indoor and outdoor) prospect, it is not essential to creating a quality Prospect experience.

There are potentially endless combinations for applying characteristics of prospect (Dosen & Ostwald, 2013). There is interior prospect, exterior prospect, as well as short depth and high depth prospect that can occur simultaneously. The complexity and variety of ways to achieve prospect is what makes it such a powerful design element. For interior spaces or dense urban spaces, prospect is the ability to see from one space to another, and is strengthened when there are clear distinctions and the opportunity to see through multiple spaces (Hildebrand, 1991).

Design considerations that may help create a quality Prospect condition:

- Orienting building, fenestration, corridors and workstations will help optimize visual access to indoor or outdoor vistas, activity hubs or destinations.
- Designing with or around an existing or planned savanna-like ecosystem, body of water, and evidence of human activity or habitation will help the information-richness of the prospect view.
- Providing focal lengths of ≥20 feet (6 meters), preferably 100 feet (30 meters); when a space has sufficient depth, spatial properties can be leveraged to enhance the experience by removing visual barriers. Limiting partition heights to 42” will provide spatial barriers while allowing seated occupants to view across a space. Understory vegetation or hedges should use a similar guide; preferred height limitations will depend on terrain and how the space is most experienced (e.g., while sitting, standing, on a bicycle).
- Locating stairwells at building perimeter with glass façade and interior glass stairwell walls can form a dual Prospect condition.
- When high ceilings are present, perimeter or interior spaces elevated 12”–18” will enhance the Prospect condition.
- Often the view quality and the balance between Prospect and [P12] Refuge will be more important than the size or frequency of the experience.
- Refer to [P1] Visual Connection with Nature to optimize the Prospect experience with a quality view.

The central courtyard of the Salk Institute for Biological Studies in California, designed by Louis Kahn, is a popular example of a nearly pure Prospect condition. This elevated space is bounded by the angled fins of the adjacent researcher offices, and has a rill flowing through the center out towards the view of the Pacific Ocean. There are some small trees in planters at the entry of the courtyard, but once in the space one’s gaze is drawn outward through the space.

Resources for digging deeper

- *The Experience of Landscape* (Jay Appleton, 1996)

Example Characteristics

Spatial Attributes

- Focal lengths ≥ 20 feet (6 meters)
- Partition heights ≤ 42 inches (hedges; opaque workplace partitions)

Common Features

- Transparent materials
- Balconies, mezzanines, catwalks, staircase landings
- Open floor plans
- Elevated planes
- Views including shade trees, bodies of water or evidence of human habitation

Above: At PDX Portland International Airport, the catwalks linking the terminal and the garage are openair, enabling outbound pedestrians to anticipate the intensity of crowds at Departures, and for those inbound to assess vehicular traffic conditions and orient themselves to the garage relative to where their car is parked. Image courtesy Catie Ryan.

Pattern
12

Refuge

* *

A place for withdrawal, from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.

Top: Cliff Palace in Mesa Verde, Colorado (constructed pre-A.D.1200s) is one of the best historic examples of designing for refuge. Image © Terry Feuerborn/Flickr.

Researched benefits to...

PHYSIOLOGICAL: Restoration, Perceived safety

PSYCHOLOGICAL: Preference, Social-emotional learning

The Experience

A space with a good Refuge condition feels safe, providing a sense of retreat and withdrawal – for work, protection, rest or healing – whether alone or in small groups. A good Refuge space feels separate or unique from its surrounding environment; its spatial characteristics can feel contemplative, embracing and protective, without unnecessarily disengaging.

Roots of the Pattern

The Refuge pattern has evolved from research on visual preference research and spatial habitat responses, and its relationship to Prospect conditions (P11). Refuge conditions are important for restoration experiences and stress reduction, which can be realized through lowered blood pressure and heart rate.

Early writings by Jay Appleton (1977, 1996), focused on Prospect–Refuge theory, and by Grant Hildebrand (1991) who has written most intelligently about Prospect and Refuge in the built environment, set good foundations for the relationship between the two patterns. In Hildebrand's words, "The edge of a wood is one of the most prevalent of natural prospect–refuge conjunctions" for it provides protection from weather and predators, but allows for outward surveillance—a perspective also supported by Dosen and Ostwald (2013). Moreover, the health response to Refuge is reportedly stronger than the response to Prospect, and the compounded response is enhanced when the two spatial conditions converge (Grahn & Stigsdotter, 2010).

In large parks, refuge spaces under trees and in vegetation bordering an open space or meadow are the preferred locations (e.g., Ruddell & Hammitt, 1987). The balance between Refuge and Prospect is suggested to be more important than the size or frequency of the experience (Appleton, 1996). In small urban parks, park size is less important than the ability to be immersed in the space with the conditions of enclosure leading to restoration (e.g., Nordh, Hartig, Hägerhäll & Fry, 2009).

Indoors, and specifically in educational environments, refuge conditions such as window seat nooks have been strongly credited by teachers with supporting social–emotional learning (O'Connor & O'Connor, 2024).

Working with the Pattern

The primary objective of the Refuge pattern is to provide users with an easily accessible and protective environment – a smaller portion of a larger space – to support restoration. The secondary objective is to limit visual access into the refuge space. The principal spatial condition is protection overhead and to one's back, preferably on three sides. Strategic placement or orientation of the space can also influence quality of experience.

Common functions of Refuge conditions:

- Weather/climate protection
- Speech or visual privacy
- Reflection or meditation
- Rest or relaxation
- Reading
- Complex cognitive tasks
- Protection from physical danger

In many cases, the refuge space provides some contact (visual or aural) with the surrounding environment for surveillance. The greater the number of protective sides, the greater the refuge condition; however, complete enclosure – protection on all sides – is not necessarily the most appropriate or effective solution, as it does not maintain a relationship to the larger space. As refuge spaces take many forms, understanding the context and defining the intended user experience will inform design decisions. Design considerations that will help create quality refuge conditions:

- Indoor refuge spaces are often characterized by lowered ceiling conditions. For spaces with standard ceiling heights, this may equate to approximately 18"–24" inches below the main ceiling.
- For indoor or outdoor spaces with particularly high ceilings (>14 feet), a more drastic differential may be necessary to achieve the desired outcome—such as with ground-up or free-standing alcoves or trellis partitions, or mezzanine structures.
- To address varying needs, preferences and acitivies, provide more than one kind of refuge space through differing spatial dimensions, lighting conditions, and degree of concealment.
- Light levels in refuge spaces should differ from adjacent spaces and user lighting controls will broaden functionality as a refuge space.

Sitting with one's back against the trunk of a big shade tree is a classic refuge space, as are lean-tos, treehouses, high backed booth seating, reading nooks and seated bay windows, and covered porches and bus stops. Cliff Palace in Mesa Verde, Colorado (constructed pre–A.D.1200s) is one of the best historic examples. While the settlement provides a feeling of containment and protection from the arid climate and potential predators or enemies, the refuge experience is enhanced with characteristics of Prospect through its elevated position and views over the canyon.

Resources for digging deeper

- *The Experience of Landscape* (Jay Appleton, 1996)
- *The Wright Space* (Grant Hildebrand, 1991)

Example Characteristics

Spatial Attributes

- Modular: Small protection (high-back chair, overhead trellis)
- Partial: Several sides covered (reading nooks, booth seating, bay window seats, canopy beds, gazebos, arcades, covered walkways, porches)
- Extensive: near or complete concealment (3+ walls: nooks, pods, mezzanines)

Design Features

- Offers weather/climate protection, or speech and visual privacy
- Supports reflection, rest, meditation, reading, or complex cognitive tasks
- Operable, adjustable or translucent (or semi-opaque) shades, blinds, screens or partitions
- Drop or lowered ceiling, soffit, overhang, or canopy
- Lower/adjustable light color, temperature or brightness

Above: Seating nook at the Gothic revival Marienburg Castle in Lower Saxony, Germany. Image by Sebastian Ganso from Pixabay

Mystery

*

The promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.

Top: Lan Su Chinese Garden, Portland, OR. Image courtesy Catie Ryan.

Researched benefits to...

COGNITIVE: Curiosity, Preference for a space

The Experience

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.

Roots of the Pattern

The Mystery pattern is largely based on the idea that people have two basic needs in environments: to understand and to explore (Kaplan & Kaplan, 1989) and that these 'basic needs' should occur "from one's current position" in order to engender a sense of mystery (Herzog and Bryce, 2007).

The Mystery pattern has evolved from research on visual preference and perceived danger, as well as pleasure responses to anticipatory situations. Mystery engenders a strong pleasure response within the brain that may be a similar mechanism to that of anticipation, which is hypothesized to be an explanation for why listening to music is so pleasurable – in that we are guessing what may be around the corner.[13] The benefits of mystery conditions are suggested to include improved preference for a space; heightened curiosity; increased interest in gaining more information.

A quality mystery condition does not engender a fear response; the conditions that differentiate between surprise (i.e., fear) and pleasure center around the visual depth of field. An obscured view with a shallow depth of field has shown to lead to unpleasant surprises, whereas greater visual access, with a medium (≥20 ft) to high (≥100 ft) depth of field is preferred (Herzog and Bryce, 2007).

A good mystery condition could also be expressed through the obscuring of the boundaries and a portion of the focal subject (i.e., room, building, outdoor space, or other information source), thereby enticing the user to anticipate the full extent of the subject and explore the space further (Ikemi, 2005).

Working with the Pattern

Mystery characterizes a place where an individual feels compelled to move forward to see what is around the corner; it is the partially revealed view ahead. The objective of the Mystery pattern is to provide a functional environment that encourages exploration in a manner that supports stress reduction and cognitive restoration. While other 'Nature of the Space' patterns can be experienced in a stationary position, mystery implies movement and analysis starting from a place perceived in a fundamentally positive way.

Mystery conditions have their place among indoor and outdoor plazas, corridors, pathways, parks, and other transitory spaces. The sense of mystery can be diluted over time and with routine exposure; however, strategies that include revolving content or information, such as peek-a-boo windows into common areas where activity is constantly changing, will be most effective in spaces routinely occupied by the same group of people

Design considerations that will help create a quality Mystery condition:

- Curving edges that slowly reveal are more effective than sharp corners in drawing people through a space.
- Dramatic shade and shadows can enhance the mystery experience. Avoid solutions that provide dark shadows or shallow depth of field that could instill unappreciated surprise or fear.
- The speed at which users are transiting through a space will influence both the size of the aperture and the size of the subject; faster typically means bigger.
- Familiar scents (fresh baked bread or cookies, spiced cider) or snippets of sound (music, laughter, crackling fire) can entice exploration through a space.
- Organically evolved mystery conditions (e.g., low maintenance gardens with winding paths) are expectedly going to change characteristics over time. These changes should be monitored as they may enhance the mystery condition, or otherwise degrade it as it evolves into a surprise condition (e.g., overgrowth of plantings leads to obscuring of depth of field).

This process of denial and reward, obscure and reveal is evident in Japanese garden design and various mazes and labyrinths throughout the world. The gardens at Katsura Imperial Villa, in Kyoto, Japan, make strong use of Mystery to draw visitors through the space and instill a sense of fascination. The strategic placement of buildings within the garden allows them to be hidden and slowly revealed at various points along the garden path, encouraging the user to explore further.

Prospect Park, in Brooklyn, New York, is an excellent example of Mystery. In classic Olmsted style—laid out in a dogleg form where boundaries are obscured in a way that lures people through the space. Key focal points in the landscape are revealed from stationary prospect points within the park. The focal points within the park (trees, buildings, lake and meadows) give the space a degree of legibility, but obscured views entice occupants to explore the space further, in order to understand it, which cannot be achieved in a single visit.

Resources for digging deeper

- *Experience of Nature* (Kaplan & Kaplan, 1989)

Example Characteristics

Spatial Attributes

- Views are medium (≥ 20 ft) to high (≥ 100 ft) depth of field
- At least one edge of the focal subject is obscured, preferably two edges
- Auditory stimulation from an imperceptible source
- Peek-a-boo windows that partially reveal
- Curving edges
- Winding paths

Common Features

- Light and shadow
- Sound or vibration
- Scent, aroma
- Activity or movement
- Artwork or installation
- Form and flow
- Translucent materials

Above: In a Vermont landscape designed by Frederick Law Olmstead, the 1,400-acre Shelburne Farms features winding pedestrian and vehicular pathways revealing historic buildings, farm animals, learning opportunities, and spectacular views along the way. Image courtesy Marshall Webb.

Risk/Peril

*

An identifiable threat coupled with a reliable safeguard.

Top: Risk/Peril experience. Image by Emma from Pixabay

The Experience

A space with a good Risk/Peril condition feels exhilarating, and with an implied threat, maybe even a little mischievous or perverse. One feels that it might be dangerous, but intriguing, worth exploring and possibly even irresistible.

Roots of the Pattern

Risk as a pattern has evolved from an understanding that perceptinos of risk are generated as a learned or biophobic response triggered by a near and present danger. This danger, however, is inert and unable to cause harm due to a trusted element of safety. The defining difference between Risk/Peril and fear is the level of perceived threat and perceived control (Rapee, 1997).

Having an awareness of a controllable risk can support positive experiences that result in strong dopamine or pleasure responses. These experiences play a role in developing risk assessment during childhood. In adults, short doses of dopamine support motivation, memory, problem solving and fight-or-flight responses; whereas, long-term exposure to intense Risk/Peril conditions may lead to over-production of dopamine, which is implicated in depression and mood disorders.[14]

Working with the Pattern

The objective of the Risk/Peril pattern is to arouse attention and curiosity, and refresh memory and problem solving skills. There are different degrees of risk that can be incorporated into a design depending on the intended user or the space available; a cantilevered walkway over a sheer cliff is an extreme case; viewing a predator in a zoo exhibit may provide a greater sense of control; whereas, rock-hopping through a gentle water feature presents the risk of getting one's feet wet.

Design considerations that will help create a quality Risk/Peril condition:

- Risk/Peril design interventions are usually quite deliberate and as such will not be appropriate for all user groups or places.

Researched benefits to...

PSYCHOLOGICAL: Mood

COGNITIVE: Risk assessment, Motivation, Memory, Problem solving

- Design strategies that rely on spatial conditions will be easier to implement when incorporated as early as concept design and schematic phases of the design process.
- The element of safety must protect the user from harm while still permitting the experience of risk.

At Frank Lloyd Wright's home, Taliesin, in Spring Green, Wisconsin, The Birdwalk is a thrilling narrow balcony that cantilevers out over the hillside. Artist Michael Heizer's Levitated Mass (pictured below) at Los Angeles County Museum of Art is an enormous boulder that spans over a pedestrian ramp, and under which visitors pass. The balancing act seems improbable, but the bracing provides some reassurance of safety, and visitors flock en masse to be photographed below the rock.

Some settings may warrant smaller interventions with lower-level perceptions of risk, such as choosing to traverse the stepping stone path through the water feature at Potsdamer Platz in Berlin, at the risk of getting wet feet, or having the option to sit directly beneath the angular lighting feature at the The Landing in Fullerton Bay Hotel in Singapore, fearing the suspended glass might fall while sipping tea or cocktails.

Resources for digging deeper

- *Risk, Challenge and Adventure in the Early Years, A practical guide to exploring and extending learning outdoors* (Sully, 2015)

Example Characteristics

Spatial Attributes

- Heights
- Gravity
- Water
- Predator-prey role reversal

Perceived Risks

- Falling
- Getting wet
- Getting hurt
- Loss of control

Features that Test Phobias

- Balcony, catwalk, cantilever
- Infinity edge
- Transparent railing, floor plane
- Experience or object that is perceived to be defying or testing gravity
- Passing under, over or through water
- Proximity to photographic or real honeybee apiary, reptile, predatory animal

The Levitated Mass at Los Angeles County Museum of Art. Michael Heizer, artist. Image © Kate Dollarhyde from Flickr.

A group carefully stepping across the water feature designed by Herbert Dreiseitl, at Potsdamer Platz in Berlin. Image courtesy Bill Browning.

Above: Angular lighting feature directly above a select area of seating at the The Landing in Fullerton Bay Hotel in Singapore. Image courtesy Catie Ryan.

Awe

* *

Stimuli that defy an existing frame of reference and lead to a change in perception.

Top: Stonehenge in southern England is a UNESCO World Heritage Site and a recognized ancient wonder. Image courtesy Lison Zhao from Unsplash

Researched benefits to...

PHYSIOLOGICAL: Heart rate, Parasympathetic nervous system ("rest and digest" activities), Inflammation

PSYCHOLOGICAL: Admiration, Respect, Enlightenment, Humility, Prosocial behaviors and tendencies (e.g.,Generosity, Sharing, Cooperativeness, Social interaction, Collective action), General well-being

COGNITIVE: Focused attention, Openness (to ideas)

The Experience

A space with a strong Awe condition emotes feelings of vastness and reappraisal. Raised eyebrows, gaping mouth, and goosebumps or chills are notable responses to an awe experience.

Roots of the Pattern

Awe has historically and primarily been a topic of contemplation in religion, sociology, psychology and philosophy. The etymology of the word "awe" is related to words that express fear and dread. In the 18th Century the conception of awe moved toward the sublime—beauty with an element of fear—such as the experience of watching a rainbow after a thunderstorm.

Awe as a design pattern is partly rooted in Abraham Maslow's concept of "peak experiences" (Maslow, 1954), whereby transformative effects of a space lead to a reconsideration of one's ego and place in the world. Today awe is understood to include beauty, that yields perceptions of transcendence (Keltner & Haidt, 2003), and can be categorized into three experiences:

- Primordial or moral awe (e.g., witnessing an especially powerful leader or the assembly of millions united in a cause),
- Experiences of nature (e.g., viewing the Grand Canyon), and
- Human art and artifacts (e.g., hearing the chorus in the 4th Movement in Beethoven's 9th Symphony; visiting the Wonders of the Modern or Ancient World).

These experiences are considered awe inspiring at a cognitive level when the specific characteristics of "vastness and accommodation" are present (Keltner & Haidt, 2003), reflecting the acknowledgement of something as being literally or figuratively immense and of embodying an intrinsic sense of goodness.

Nonsocial stimuli, such as natural wonders, panoramic views, and art may elicit prosocial behaviors or tendencies (Piff et al., 2015) such as generosity, humility, sharing, cooperativeness, collective action and integration into social groups (e.g., Bai et al., 2017). Well-being benefits may also include lower heart rate, arousal of the parasympathetic "rest-and-digest" system, lower levels of inflammation (Stellar et al., 2015) and improved capacity for focused attention (van Elk et al., 2019).[15]

Working with the Pattern

The objective of the Awe pattern is to balance perceptions of pleasure and fear (Keltner & Haidt, 2003) to increase prosocial behavior and ethical decision-making among a user group. Whether spatial, ephemeral, or concrete in nature, experiences of awe with positive emotional valence suggest an intrinsic attractiveness (aesthetics). The built environment is best positioned to offer physical elicitors, either through enabled access (to a grand vista) or through space, volume, light, or scale. We can look to nature for analogues and spatial conditions to help envision what vastness and accommodation look like at different scales.

- Large objects (tall trees mountains, cliffs, oceans, deep canyons) or ephemeral moments (sunsets, rainbows, aurora borealis);
- Small objects with immense complexity relative to their size (a hovering hummingbird, exquisite miniature art); and
- Objects with a sense of infinite repetition (waves, flames) or boundlessness (open ocean, Milky Way).

One's openness (to experience), sense of self (ego), attention, knowledge, are all factors in their response to an awe experience (Silvia et al., 2015). With this in mind, designing in affordances (e.g., signage, seating, change in acoustic properties, activity programming) may help to subconsciously guide a person to a given awe experience. Research gives us the following qualitative considerations for working with awe as a design pattern:

- Treat spatial transitions as opportunities for contrasts: Dark lows leading to soaring heights—what Frank Lloyd Wright called "compression and release"; and thresholds between boundaries of the secular and the sacred or numinous, also known as "thin spaces".
- When vistas of sky, ocean, mountains or sunsets are not possible, consider awe-inspiring images of nature (Piff et al., 2015).
- Incorporate places and programs that celebrate a culture of knowledge, collaboration, skill/craft mastery, and the exploration or contemplation of the unknown.

Awe can be vast in scale or age, like the Grand Canyon (USA), the pyramids of Giza (Egypt) and Stonehenge (England). Urban skylines, architectural icons, and bird's eye views are often at the center of awe-inducing moments, such as from observation decks atop the Empire State Building (USA) and the Merdeka 118 (Malaysia), and from places of creative or spiritual significance like at Notre-Dame Cathedral (France), Taj Mahal (India), or the Sagrada Familia (Spain), which are vast in skill, artistry, size and capacity, and took more than a lifetime to construct.

Resources for digging deeper

- *Awe, The New Science of Everyday Wonder and How it Can Transform your Life* (Dacher Keltner, 2023)
- *Thin Place Design: Architecture of the Numinous* (Phillip James Tabb, 2023)

Example Characteristics

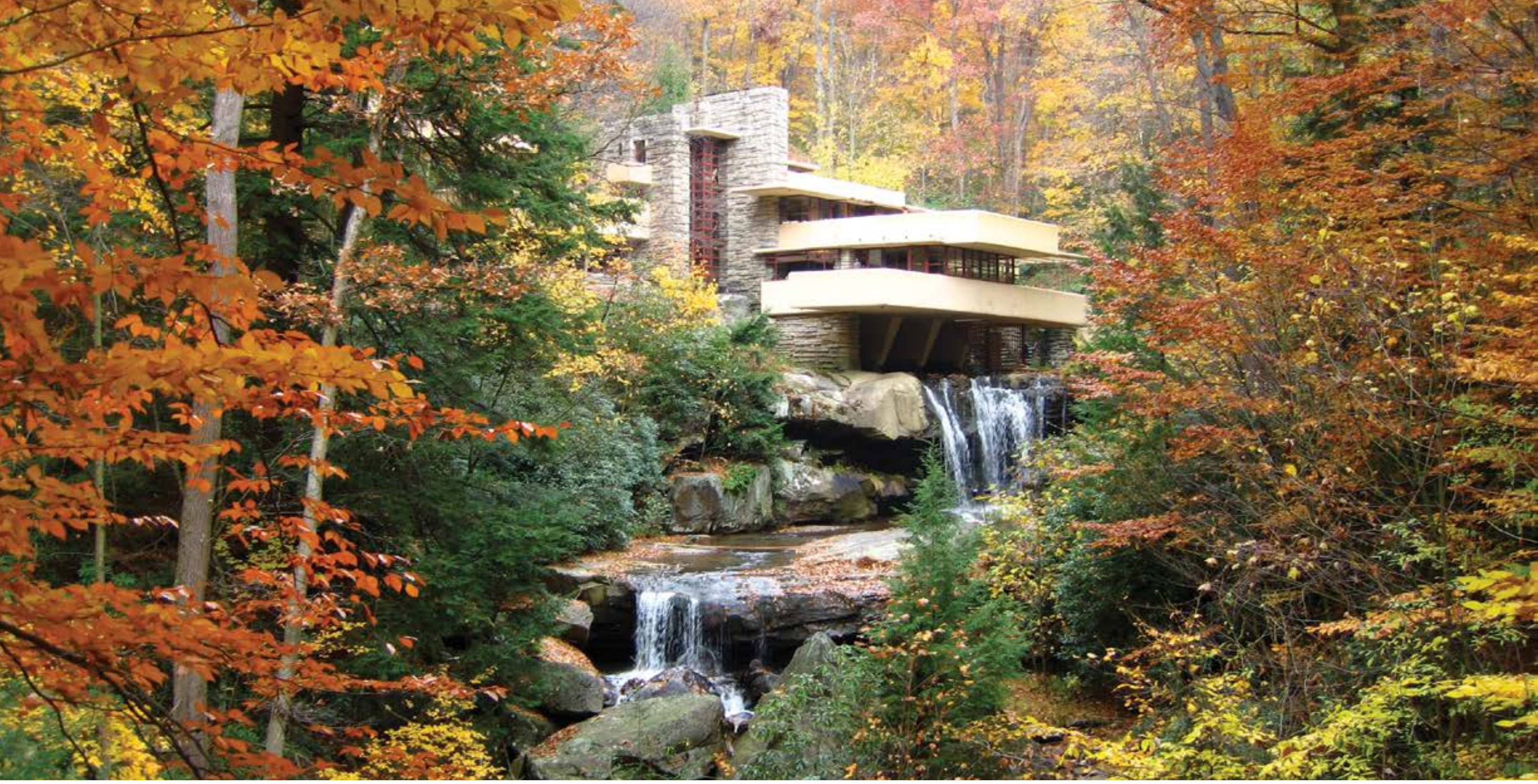
Spatial Attributes

- Larger than human scale (e.g., size, time, breadth, prestige, fame)
- Transitions at the boundaries of the secular and sacred or numinous
- Immersive, Absorptive

Common Features

- Organization of an incalculable quantity of something
- Remarkable simplicity or lavishness
- Alignment of natural cycles or phenomena
- Infinity conditions
- Sounds and movement
- Night sky preservation

Above: Designed by Antoni Gaudí, la Sagrada Familia Basilica in Barcelona, Spain, soaring and biomorphic forms, was construction from 1882–2010. Image © Simon Maage from Unsplash.



Closing Thoughts from the Authors

Fallingwater by Frank Lloyd Wright, Bear Run, PA. Image © Brandon Sargent/Flickr.

Though the science supporting biophilic design is still emerging, in many ways it could be argued that the research is really just corroborating the rediscovery of the intuitively obvious. Unfortunately, too much of our modern design is oblivious to this profound knowledge. Deep down, we know that the connection with nature is important. When asking people to think about their favorite places for vacation, the majority will describe somewhere outdoors; we use the term 'recreation' and forget that recreation is about recreating—restoring ourselves. So while empirical evidence continues to accumulate, we ought to go about restoring the human-nature connection in the built environment.

Just to remind ourselves why biophilic design is so important, consider that in the 12,000 years since humans began farming and other activities that transformed the natural landscape, only in the last 250 years have modern cities become common. Only recently have we became urban dwellers, with more people living in cities than in the countryside. In coming decades, it is projected that 70 percent of the world's population will live in cities. With this shift, the need for our designs to (re)connect people to experiences of nature becomes ever more important. Biophilic design is not a luxury, it's a necessity for the health and well-being of everyone.

We hope "14 Patterns of Biophilic Design" continues to shed light on the importance of and opportunity for human connections with nature in our built environments. We encourage people to challenge convention by bringing biophilic design patterns into their vision for healthy and regenerative homes, schools, workplaces, communities, and cities.

"Maybe we don't know everything there is to know about human benefits of nature contact, but we have a pretty fair idea, and we know a lot about designing nature into the built environment. And given the pace at which decisions are being made and places built, there is a pressing need to implement what we know. We can't wait for the research."

Howard Frumkin, 2008
Nature Contact and Human Health, Biophilic Design

Appendix 1: Endnotes

[1a] Visual Connection with Nature. Stress recovery from visual connections with nature have reportedly been realized through lowered blood pressure and heart rate (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005); reduced attentional fatigue, sadness, anger, and aggression; improved mental engagement/ attentiveness (Biederman & Vessel, 2006), attitude and overall happiness (Barton & Pretty, 2010).

There is also evidence for stress reduction related to both experiencing real nature and seeing images of nature (e.g., Grahn & Stigsdotter, 2010; Kahn, Severson & Ruckert, 2009; Bloomer, 2008; Kahn, Friedman, Gill et al., 2008; Hartig et al., 2003; Leather et al., 1998), that natural environments are generally preferred over built environments (e.g., van den Berg, Koole & van der Wulp, 2003; Hartig, 1993; R. Kaplan & Kaplan, 1989; Knopf, 1987; Ulrich, 1983).

Visual access to biodiversity is reportedly more beneficial to our psychological health than access to land area (i.e., quantity of land) (Fuller, Irvine, Devine-Wright et al., 2007).

[1b] Positive impact on mood and self-esteem has been shown to occur most significantly in the first five minutes of experiencing nature, such as through exercise within a green space (Barton & Pretty, 2010). Viewing nature for 10 minutes prior to experiencing a mental stressor has shown to stimulate heart rate variability and parasympathetic activity (i.e., regulation of internal organs and glands that support digestion and other activities that occur when the body is at rest) (Brown, Barton & Gladwell, 2013), while viewing a forest scene for 20 minutes after a mental stressor has shown to return cerebral blood flow and brain activity to a relaxed state (Tsunetsugu & Miyazaki, 2005). Even a 40-second view of nature calms the prefrontal cortex and restores cognitive capacity (Lee et al., 2015).

[2] Non-Visual Connection with Nature. This pattern is derived from data on reductions in systolic blood pressure and stress hormones (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991), impact of sound and vibration on cognitive performance (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004), and perceived improvements in mental health and tranquility as a result of non-visual sensory interactions with non-threatening nature (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003).

[3] **Non-Rhythmic Sensory Stimuli.** This pattern has evolved from research on looking behavior (particularly periphery vision movement reflexes); eye lens focal relaxation patterns (Lewis, 2012; Vessel, 2012); heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2010; Park, Tsunetsugu, Ishii et al., 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich, Simmons, Lostio et al., 1991); and observed and quantified behavioral measures of attention and exploration (Windhager et al., 2011).

[4a] **Thermal & Airflow Variability.** This pattern has evolved from research measuring the effects of natural ventilation, its resulting thermal variability, and worker comfort, well-being and productivity (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005), physiology and perception of temporal and spatial alliesthesia (pleasure) (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979), Attention Restoration Theory and impact of nature in motion on concentration (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989) and, generally speaking, a growing discontent with the conventional approach to thermal design, which focuses on trying to achieve a narrow target area of temperature, humidity and air flow while minimizing variability (e.g., de Dear, Brager & Cooper, 1997).

[4b] Heerwagen (2006) explained that evidence has shown that people like moderate levels of sensory variability in the environment, including variation in light, sound and temperatures, (e.g., Elzeyadi, 2012; Humphrey, 1980; Platt, 1961), and that an environment devoid of sensory stimulation and variability can lead to boredom and passivity (e.g., Schooler, 1984; Cooper, 1968).

[5] **Presence of Water.** This pattern has evolved from research on visual preference for and positive emotional responses to environments containing water elements (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006;Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983); reduced stress, increased feelings of tranquility, lower heart rate and blood pressure, and recovered skin conductance from exposure to water features (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006); improved concentration and memory restoration induced by complex, naturally fluctuating visual stimuli (Alvarsson et al., 2010; Biederman & Vessel, 2006); and enhanced perception and psychological and physiological responsiveness when multiple senses are stimulated simultaneously (Alvarsson et al., 2010; Hunter et al., 2010).

[6] **Diffuse & Dynamic Light.** Early research showed that productivity is higher in well daylighted work places, and sales are higher in daylit stores (e.g., Browning & Romm, 1994), and that children performed better in daylighted classrooms with views (e.g., Heschong Mahone, 2003; 1999) – the research focus was on lighting strategy and task performance and less on human biology. Recent research has focused more heavily on illuminance fluctuation and visual comfort (Elyezadi, 2012; Kim & Kim, 2007), human factors and perception of light (e.g., Leslie & Conway, 2007; Nicklas & Bailey, 1996), and impacts of lighting on the circadian system functioning (e.g., Kandal et al., 2013; Figueiro, Brons, Plitnick, et al., 2011; Beckett & Roden, 2009).

[9] **Material Connection with Nature.** One possible explanation for our biophilic response to stone and wood is that the brain makes a series of associations. For instance, the brain subconsciously links wood to trees and trees to life and nature. This associative processing is what is believed to trigger a biophilic response (Vessel, et al. 2018; Vessel, 2012; Rametsteiner et al., 2007). Wood grain is essentially a series of collinear striations or line patterns that are broken into segments to form nested contours. Studies indicate that lines running in the same direction are processed by a single set of neurons in the brain; whereas, when lines are running in multiple directions, multiple sets of neurons are needed (i.e., more effort) to process what is being viewed (Gilbert, 2014). The brain will follow curvatures and contours (Li, 2002) and even connect short segments of lines to discern a longer curving pattern (Li, et al., 2008). These pattern conditions occur frequently in nature, and it could be argued that our brains are predisposed

to easily decipher them (i.e., fractal fluency), which would further explain why experiencing such patterns can lower stress (Albright, 2002).

[10] Complexity & Order. This pattern has evolved from research on fractal geometries and preferred views (Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006); the perceptual and physiological stress responses to the complexity of fractals in nature, art and architecture (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988); and the predictability of the occurrence of design in nature (Bejan & Zane, 2012).

[11] Prospect. Visual preference research and spatial habitat responses have informed the evolution of this pattern, as well as cultural anthropology, evolutionary psychology (e.g., Heerwagen & Orians, 1993) and architectural analysis (e.g., Dosen & Ostwald, 2013; Hildebrand, 1991; Appleton, 1996). Health benefits are suggested to include reduced stress (Grahn & Stigsdotter, 2010); reduced boredom, irritation, fatigue (Clearwater & Coss, 1991), and perceived vulnerability (Petherick, 2000; Wang & Taylor, 2006); as well as improved comfort (Herzog & Bryce, 2007).

[13] Mystery. The characteristics of mystery conditions are based on visual preference and perceived danger (Herzog & Bryce, 2007; Herzog & Kropscott, 2004; Nasar, & Fisher, 1993), and supported by research on pleasure responses to anticipatory situations (Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001). Mystery engenders a strong pleasure response within the brain that may be a similar mechanism to that of anticipation (Biederman, 2011), which is hypothesized to be an explanation for why listening to music is so pleasurable – in that we are guessing what may be around the corner (Blood & Zatorre, 2001; Salimpoor et al., 2011).

[14] Risk/Peril. Having an awareness of a controllable Risk can support positive experiences (Van den Berg & ter Heijne, 2005) that result in strong dopamine or pleasure responses (Kohno et al., 2015; Wang & Tsien, 2011; Zald et al., 2008). These experiences play a role in developing risk assessment during childhood (Louv, 2009; Kahn & Kellert, 2002). In adults, short doses of dopamine support motivation, memory, problem solving and fight-or-flight responses; whereas, long-term exposure to intense Risk/Peril conditions may lead to over-production of dopamine, which is implicated in depression and mood disorders (Buraei, 2014; Kandel et al., 2013).

[15] Awe. Stellar et al. (2017) look at the characteristics and health outcomes of both the light and dark sides of awe experiences. Research from Anderson, Monroy and Keltner (2018) looks at how Awe in nature heals, particularly among military veterans, at-risk youth, and college students. Piff et al. (2015) summarize the writings of others to highlight that "accounts of awe felt during experiences with religion and spirituality, nature, art, and music often center upon two themes: the feeling of being diminished in the presence of some-thing greater than the self, and the motivation to be good to others''. Their research also revealed that "awe leads to increased generosity via the small self"…and "the awe condition led to significant increases in small self-ratings and ethical decision-making". Gottlieb, Keltner and Lombrozo (2018), have assessed the tendency to experience awe is positively associated with scientific thinking, which speaks to an individual's openness, while Perlin and Li (2020) look at perspectives on why Awe has prosocial effects and the concept of the small self. The small self is also addressed in research by van Elk et al. (2019) on immersive awe experiences that reduced mind wandering and self-reflerential processing and supported greater attention.

Appendix 2a: Health Outcomes from Biophilic Experiences with Research Citations

	Biophilic Pattern	Physiological Stress Reduction	Cognitive Performance	Emotion, Mood & Preference
NATURE IN THE SPACE	★★★ **Visual Connection with Nature**	• **Lowered systolic blood pressure and heart rate** (Yin et al., 2018; Li & Sullivan, 2016; Song et al., 2017; Lee et al., 2009; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005; Hartig et al., 2003; Ulrich, Simons, Losito et al., 1991) • **Increased parasympathetic activity** (Brown, Barton & Gladwell, 2013) • **More effective physiologial relaxation** (Joung et al., 2015)	• **Improved mental engagement and attentiveness / sustained attention** (Li & Sullivan, 2016; Lee et al., 2015; Biederman & Vessel, 2006; Mayer et al., 2009; Ulrich, Simons, Losito et al., 1991)	• **Positively impacted attitude and overall happiness** (Barton & Pretty, 2010; An et al., 2016; Mayer et al., 2009; Hartig et al., 2003) • **Reduced future discounting** (van der Wal et al., 2013) • **Heightened appreciation for nature** (Mayer et al., 2009) • **Decreased rumination** (Bratman et al., 2015) • **Correlation between view preference and motivation** (Yue, Vessel & Biederman, 2007) • **More effecitve psychological relaxation** (Joung et al., 2015)
NATURE IN THE SPACE	★★★ **Non-Visual Connection with Nature**	AUDITORY EXPERIENCE: • **Reduced systolic blood pressure and stress hormones** (Annerstedt et al., 2013; Alvarsson et al., 2010; Li et al., 2012) OLFACTORY EXPERIENCE: • **Improved immune function** (Li et al., 2012) • **Improved cardio-respiratory response** (Grote et al., 2021) HAPTIC EXPERIENCE: • **Maintained joint flexibility** (Yamane et al., 2004) • **Relaxation through a change in cerebral blood flow rates** (e.g., Koga & Iwasaki, 2013)	• **Positively impacted cognitive performance** (Hedger et al., 2019; Van Hedger et al., 2019; Haapakangas et al., 2011; Abbott et al., 2016; Warm & Dember, 1991) • **Improved creativity** (Haapakangas et al., 2011) • **Reduced cognitive fatigue** (Jahncke, et al., 2011) • **Reduced self-reported fatigue** (Yamane et al., 2004)	• **Perceived improvements in mental health, tranquility, and pain management** (Krzywicka & Byrka, 2017; Benfield et al., 2014; Jahncke, et al., 2011; Alvarsson et al., 2010; Pheasant et al., 2010; Tsunetsugu, Park, & Miyazaki, 2010; Watts et al., 2009; Kim, Ren, & Fielding, 2007) • **Improved preference** (Haapakangas et al., 2011) • **Olfactory-induced energy moderation** (Harada et al., 2018) • **Haptics-induced improvement in environmental stewardship among children** (Yamane et al., 2004)
NATURE IN THE SPACE	★★ **Non-Rhythmic Sensory Stimuli**	• **Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity** (Beauchamp, et al., 2003; Ulrich, Simons, Losito et al., 1991)		• **Increase dwell time and observed behavioral measures of attention and exploration** (Windhager et al., 2011)
NATURE IN THE SPACE	★★ **Thermal & Airflow Variability**	• **Positively impacted comfort, well-being and productivity** (Heerwagen, 2006; Wigö, 2005) • **Fewer self-reported Sick Building Syndrome cases** (Tham & Willem, 2005)	• **Improved task performance** (Tham & Willem, 2005; Wigö, 2005)	• **Improved perception of temporal and spatial pleasure (alliesthesia)** (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
NATURE IN THE SPACE	★★ **Presence of Water**	• **Reduced stress, increased feelings of tranquility, lowered heart rate and blood pressure** (Galbrun & Ali, 2013; Annerstedt et al., 2013; Haapakangas et al., 2011; Alvarsson, Wiens, & Nilsson, 2010; Pheasant et al., 2010)	• **Positively impacted cognitive performance and creativity** (Haapakangas et al., 2011)	• **Improved preferences and positive emotional responses** (Haapakangas et al., 2011; Jahncke et al., 2011; Hunter et al., 2010; Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Ruso & Atzwanger, 2003; Watts et al., 2009; Biederman & Vessel, 2006)
NATURE IN THE SPACE	★★★ **Dynamic & Diffuse Light**	• **Positively impacted circadian system functioning** (Figueiro et al., 2018; Figueiro et al., 2017; Boubekri et al., 2014; Elzeyadi, 2011; Figueiro, Brons, Plitnick et al., 2011) • **Increased visual comfort** (Elzeyadi, 2012)	• **Improvements to cognitive and behavioral performance** (Keis et al., 2014; Mott et al., 2012; Mott et al., 2014; Boubekri et al., 2014)	• **Positively impacted attitude and overall happiness** (An et al., 2016)
NATURE IN THE SPACE	**Connection with Natural Systems**	• **Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)		• **Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)
NATURAL ANALOGUES	★ **Biomorphic Forms & Patterns**	• **Improved stress recovery** (Determan et al., 2019)	• **Improved learning outcomes** (Determan et al., 2019)	• **Increased view preference** (Joye, 2007; Kardan et al., 2015)
NATURAL ANALOGUES	★★ **Material Connection with Nature**	• **Decreased diastolic blood pressure** (Sakuragawa, Kaneko & Miyazaki, 2008; Tsunetsugu, Miyazaki & Sato, 2007; Morikawa, Miyazaki, & Kobayashi, 1998) • **Improved comfort** (Tsunetsugu, Miyazaki & Sato, 2007) • **Reduced plasma cortisol level** (Ohta et al., 2008) • **Increased parasympathetic (rest and calming) activity** (Ikei, Song & Miyazaki, 2017) • **Increased heart rate variability** (Kelz, Grote & Moser, 2011) • **Self-reported calming effect** (Rice et al., 2006)		• **Improved material preference** (Jimenez et al., 2016; Høibø & Nyrud, 2010; Nyrud & Bringslimark, 2010; Nakamura & Kondo, 2008; Berger, Katz & Petutschnigg, 2006; Rice et al., 2006)
NATURAL ANALOGUES	★★ **Complexity & Order**	• **Positively impacted perceptual and physiological stress responses** (Determan et al., 2019; Salingaros, 2012; Joye, 2007; Taylor, 2006)	• **Brainwave response indicative of relaxation** (Hagerhall et al., 2008) • **Improved environmental navigation** (Juliani et al., 2016) • **Improved learning outcomes** (Determan et al., 2019)	• **Subjective improvement to mood and preference** (Abboushi et al., 2019; Bies et al., 2016; Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Taylor, 2006 Hägerhäll, Purcella, & Taylor, 2004)
NATURE OF THE SPACE	★★★ **Prospect**	• **Reduced stress** (Grahn & Stigsdotter, 2010) • **Improved comfort and perceived safety** (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)		• **Reduced boredom, irritation, fatigue** (Clearwater & Coss, 1991) • **Improved visual preference** (Mumcu, Duzenli & Özbilen, 2010; Wiener et al., 2007)
NATURE OF THE SPACE	★★ **Refuge**	• **Restoration** (Nordh, Hartig, Hägerhäll & Fry, 2009) • **Improved perception of safety** (Dosen & Ostwald 2013; Petherick, 2000)		• **Improved visual preference** (Grahn & Stigsdotter, 2010; Petherick, 2000; Ruddell & Hammitt, 1987) • **Social-emotional learning** (O'Connor & O'Connor, 2024)
NATURE OF THE SPACE	★ **Mystery**			• **Improved visual preference** (Herzog & Bryce, 2007; Kent, 1989) • **Induced pleasure** (Ikemi, 2005)
NATURE OF THE SPACE	★ **Risk/Peril**			• **Induced dopamine/pleasure** (Kohno et al., 2015; Wang & Tsien, 2011)
NATURE OF THE SPACE	★★ **Awe**	• **Reduced stress related symptoms** (Anderson, Monroy & Keltner, 2018; Stellar et al., 2017) • **Increased parasympathetic activity** (Stellar et al., 2015) • **Lower levels of inflammation** (Stellar et al., 2015)	• **Improved capacity for attention** (van Elk et al., 2019) • **Reduced self-referential processing** (van Elk et al., 2019; Perlin & Li, 2020)	• **Increased pro-social behavior** (Anderson, Monroy & Keltner, 2018; Stellar et al., 2018; Bai et al., 2017; Piff et al., 2015; Stellar et al., 2015) • **Positively impacted attitude and overall happiness** (Anderson, Monroy & Keltner, 2018)

SOURCE: Health Outcomes from Biophilic Experiences | 14 Patterns of Biophilic Design | Browning, Ryan & Clancy, 10th Anniversary Edition, 2024. New York: Terrapin Bright Green, LLC.

Health Outcomes from Biophilic Experiences Key Benefits by Research

	Biophilic Pattern	Physiological Stress Reduction	Cognitive Performance	Emotion, Mood & Preference
Nature in the Space	**Visual Connection with Nature**	Heart rate, Blood pressure, Parasympathetic system activity	Mental engagement, Attentiveness	Attitude, Neurological rumination, Motivation, Future discounting
	Non-Visual Connection with Nature	Blood pressure, Stress hormones, Immune function, Relaxation, Joint flexibiltty	Cognitive performance and fatigue recovery, Creativity	Perceived mental health, Tranquility, Pain management, Energy moderation, Environmental sewardship
	Non-Rhythmic Sensory Stimuli	Heart rate, Systolic blood pressure, Sympathetic nervous system		Dwell time, Behavioral attention and exploration
	Thermal & Airflow Variability	Comfort, Well-being, Productivity	Task performance, Productivity	Preceived temporal and spatial pleasure (alliesthesia)
	Presence of Water	Overall stress, Heart rate, Blood pressure	Cognitive performance, Creativity	Positive emotion, Tranquility
	Dynamic & Diffuse Light	Circadian system functioning, Visual comfort	Cognitive and behavioral performance	Attitude, Overall happiness
	Connection w/ Natural Systems	Overall health		Perception of environment
Natural Analogues	**Biomorphic Forms & Patterns**	Stress recovery	Learning outcomes	View preference
	Material Connection with Nature	Heart rate variability, Comfort, Calming, Blood pressure, Stress hormones	Task performance, Creativity	Material preference
	Complexity & Order	Perceptual and physiological stress responses	Environmental navigation, Learning outcomes, Mental relaxation	View preference
Nature of the Space	**Prospect**	Overall stress, Perceived safety, Comfort		Visual interest, Fatigue, Irritation, Boredom
	Refuge	Restoration, Perceived safety		Visual preference, Social-emotional learning
	Mystery			Pleasure response, Visual preference
	Risk/Peril			Pleasure response
	Awe	Stress related symptoms, Increased parasympathetic activity, Reduced inflammation	Capacity for attention, Reduced self-referential processing	Pro-social behavior, Attitude, Overall happiness

SOURCE: Health Outcomes from Biophilic Experiences | 14 Patterns of Biophilic Design | Browning, Ryan & Clancy, 10th Anniversary Edition, 2024. New York: Terrapin Bright Green, LLC.

Appendix 3: Recommended Readings

Other publications by Terrapin

The Economics of Biophilia
Why designing with nature in mind makes financial sense (2nd ed.)

Biophilic Design with Wood in British Columbia (Forestry Innovation Investment Ltd.)

The Nature of Wood
An exploration of the science on biophilic responses to wood

Working with Fractals
A resource for practitioners of biophilic design

Nature Inside
A Biophilic Design Guide (RIBA Publishing)

Malibu Rebuilder Guide
Recommendations for a Fire-Resilient, Resource-Efficient and Affordable New Home (Malibu Foundation)

The Nature of Air
Economic & Bio-Inspired Perspectives on Indoor Air Quality Management

An Ear for Nature
Psychoacoustic Strategies for Workplace Distractions & The Bottom Line

Human Spaces 2.0
Biophilic Design in Hospitality (Interface, Inc.)

Midcentury (Un)Modern
An Environmental Analysis of the 1958–73 Manhattan Office Building

Tapping Into Nature
The Future of Energy, Innovation & Business

More great reads

Awe
The new science of everyday wonder and how it can transform your life by Dacher Keltner

A New Pattern Language for Growning Regions
Places, Networks, Processes by Michael Mehaffy

Biophilia
The human bond with other species by Edward O. Wilson

Biophilia & Healing Environments
Healthy Principles for Designing the Built World by Nikos Salingaros

Biophilic Cities
Integrating Nature into Urban Design and Planning by Timothy Beatley

Biophilic Design
The Theory, Science and Practice of Bringing Buildings to Life by Stephen R. Kellert, Judith H. Heerwagen & Martin L. Mador

Biophilic Design and Climate Change
Performance Parameters for Health by Julia Africa, Judith Heerwagen, Vivian Loftness & Catherine Ryan Balagtas

Cognitive Architecture
Designing for how we respond to the built environment by Ann Sussman & Justin B. Hollander

Creating Biophilic Buildings
by Amanda Sturgeon

Creating Sensory Spaces
The Architecture of the Invisible by Barbara Erwine

Design for a Living Planet
Settlement, Science and the Human Future by Michael Mehaffy & Nikos Salingaros

The Experience of Landscape
by Jay Appleton

Experiential Design Schemas
by Mark DeKay & Gail Brager

Fractal Fluency in the Built Environment
by Fractals Research and 13&9 Design

Nature by Design
The Practice of Biophilic Design by Stephen R. Kellert

Nature Fix, The
Why Nature Makes Us Happier, Healthier, and More Creative by Florence Williams

Practice of Biophilic Design, The
by Stephen R. Kellert & Elizabeth F. Calabrese

Restorative Cities
Urban Design for Mental Health and Wellbeing by Jenny Roe & Layla McCay

Thermal Delight In Architecture
by Lisa Heschong

Thin Place Design
Architecture of the Numinous by Phillip James Tabb

Urban Experience and Design
Contemporary Perspectives on Improving the Public Realm, by Justin B. Hollander (Editor) & Ann Sussman

Visual Delight in Architecture
Daylight, Vision and View by Lisa Heschong

Appendix 4: Patterns In Translation

Chinese
15种亲生命性设计模式

空间中的自然

1. 与大自然的视觉联系
2. 与大自然的非视觉联系
3. 非律动性感觉刺激
4. 热舒适与气流变化
5. 水的存在
6. 动态与漫射光
7. 连接自然系统

自然类比

8. 仿生形态与规律
9. 材料连接与自然
10. 复杂性与秩序

空间的本质

11. 前景
12. 避难所
13. 神秘感
14. 风险/冒险
15. 敬畏

Translation credit:
Keenan Chen and Allison Bernett

Dutch
15 Biofiel Ontwerp Partonen

Natuur in de Ruimte

1. Visueel contact met de Natuur
2. Non-Visueel Contact met de Natuur
3. Non-Ritmische zintuigelijke prikkels
4. Warmte – en luchtstoomvariabiliteit
5. Aanwezigheid van water
6. Dynamisch en diffuus licht
7. Contact met natuurlijke systemen

Natuurlijke Analogen

8. Biomorfe vormen en patronen
9. Materialistisch contact met de natuur
10. Complexheid & Volgorde

Natuur van de Ruimte

11. Vergezicht
12. Toevlucht
13. Mysterie
14. Risico/gevaar
15. Verwondering / Ontzag

Translation credit:
Biophilix®, Belgium

Filipino
15 mga hulma ng disenyong biopilic

Kalikasan sa espasyo

1. Nakikitang koneksyon sa kalikasan
2. Mga di nakikitang koneksyon sa kalikasan
3. Walang ritmong pamukaw sa pandama
4. Pagkakaiba-iba ng init at daloy ng hangin
5. Pagkakaroon ng tubig
6. Pagkakaiba iba at pagkakalat ng liwanag
7. Koneksyon sa mga natural na sistema

Natural na mga analogo

8. Hugis at dibuhong kalikasan
9. Materyal na koneksyon sa kalikasan
10. Masikot at maayos

Kalikasan ng espasyo

11. Malawak na pagtingin / Panorama
12. Kanlungan
13. Misteryo
14. Panganib
15. Kagilagilalas

Translation credit:
Charlie V. Balagtas
Partido State University, Philippines

Patterns In Translation (cont.)

French
15 Modéles de Conception Biophilique

Nature dans l'espace

1. Lien visuel avec la nature
2. Lien non-visuel avec la nature
3. Stimulations sensorielles non-rythmiques
4. Variabilité thermique et renouvellement d'air
5. Présence de l'eau
6. Lumière dynamique et diffuse
7. Lien avec les systèmes naturels

Analogies naturelles

8. Modèles et formes biomorphiques
9. Lien matériel avec la nature
10. Complexité et ordre

Nature de l'espace

11. Perspective
12. Refuge
13. Mystère
14. Risque
15. Admiration / Impressionnant

Translation credit:
ARP-Astrance, France

German
15 Muster des Biophilen Designs

Natur im Raum

1. Visuelle Verbindung mit der Natur
2. Nicht visuelle Verbindung mit der Natur
3. Nicht-rhythmische Sensorische Stimuli
4. Thermal- und Luftstromvariabilität
5. Präsenz von Wasser
6. Dynamisches und Diffuses Licht
7. Verbindung mit Natürlichen Systemen

Natürliche Analogien

8. Biomorphe Formen und Muster
9. Materielle Verbindung mit der Natur
10. Komplexität und Ordnung

Natur des Raumes

11. Aussicht
12. Zuflucht
13. Geheimnis
14. Risiko/Gefahr
15. Ehrfurcht (Ehrfurcht erregend)

Translation credit:
Claudio Lai
Art Aqua, Germany

Interface, Germany

Hebrew
15 דפוסי תכנון ביופיליים

טבע במרחב

1. חיבור ויזואלי עם הטבע
2. חיבור שאינו ויזואלי עם הטבע
3. גירוי חושי אקראי
4. גיוון תרמי וזרימת אוויר
5. נוכחות מים
6. אור מפוזר ודינמי
7. חיבור עם מערכות טבעיות

אנלוגיות לטבע

8. צורות ודפוסים אורגניים
9. חומרים טבעיים
10. מורכבות וסדר

טבעו של המרחב

11. מבט למרחב
12. מסתור
13. מסתורין
14. סיכון
15. התפעמות

Translation credit:
Chen Shalita
Alfa Sustainable Projects

Patterns In Translation (cont.)

Italian
15 Pattern della Progettazione Biofilica

Natura nello spazio

1. Connessione visiva con la natura
2. Connessione non visiva con la natura
3. Stimoli sensoriali non ritmici
4. Variabilità termica e del flusso d'aria
5. Presenza dell'acqua
6. Luce dinamica e diffusa
7. Connessione con i sistemi naturali

Analoghi naturali

8. Forme e pattern biomorfici
9. Connessione materiale con la natura
10. Complessità e ordine

Natura dello spazio

11. Prospettiva
12. Rifugio
13. Mistero
14. Rischio/Pericolo
15. Meraviglia

Translation credit:
Rita White
Accademia Italiana di Biofilia, Italy

Stefano Serafini
International Society of Biourbanism, Italy

Korean
바이오필릭 디자인의 15 가지 패턴

공간 내 자연

1. 자연과의 시각적 연결
2. 자연과의 비시각적 연결
3. 불규칙적 감각 자극
4. 온도 및 공기 흐름 변화
5. 물의 존재
6. 빛의 변화와 확산
7. 자연시스템 연결

자연의 모사

8. 바이오모픽적 형태와 패턴
9. 자연과의 물질적 연결
10. 복잡성과 질서

자연적 공간

11. 전망
12. 은신처
13. 미스터리
14. 위험 / 위기
15. 경외감

Translation credit:
Professor Yeol Park
TYP Urban Architecture Studio, South Korea

Portuguese
15 Padrões de Design Biofílico

Natureza no espaço

1. Conexão Visual com a Natureza
2. Conexão Não-Visual com a Natureza
3. Estímulo Sensorial Não-Rítmico
4. Variação Térmica e de Fluxo de Ar
5. Presença de Água
6. Luz Dinâmica e Difusa
7. Conexão com os Sistemas Naturais

Analogias Naturais

8. Formas e Padronagens Biomórficas
9. Conexão dos Materiais com a Natureza
10. Complexidade e Ordem

Natureza do espaço

11. Panorama
12. Refúgio
13. Mistério
14. Risco/Perigo
15. Admiração / Maravilha

Translation credit:
Luciana Spinola
COOKFOX Architects DCP, USA

Patterns In Translation (cont.)

Russian

15 паттернов биофильного дизайна

Природа в пространстве

1. Визуальная связь с природой
2. Невизуальная связь с природой
3. Неритмичные сенсорные раздражители
4. Переменчивость температуры и воздушных потоков
5. Присутствие воды / Наличие воды
6. Динамический и рассеянный свет
7. Связь с естественной природой

Природные Аналоги

8. Биоморфные формы и паттерны
9. Материальная связь с природой
10. Сложность и порядок

Природа Пространства

11. Перспектива (разведка, панорама, вид)
12. Убежище / Уединенное место
13. Тайна / Таинственность
14. Риск / Опасность
15. благоговение / Изумление (вызвать созерцание)

Translation from:
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Spanish

15 Patrones de Diseño Biofílico

Naturaleza en el espacio

1. Conexión visual con la naturaleza
2. Conexión no visual con la naturaleza
3. Estímulos sensoriales no rítmicos
4. Variabilidad térmica y de flujos de aire
5. Presencia de agua
6. Luz dinámica y difusa
7. Conexión con sistemas naturales

Analogías naturales

8. Formas y patrones biomórficos
9. Conexión de los materiales con la naturaleza
10. Complejidad y orden

Naturalez del espacio

11. Panorama
12. Refugio
13. Misterio
14. Riesgo/Peligro
15. Asombro (Cualquier combinación de características espaciales que provoque el efecto de abrir los ojos en sorpresa o quedarse con la boca abierta.)

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Appendix 5: References

For space efficiency, ISO 4 standard abbreviations are used for journal titles where applicable.

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Appendix 6: Press–Ready Postcards

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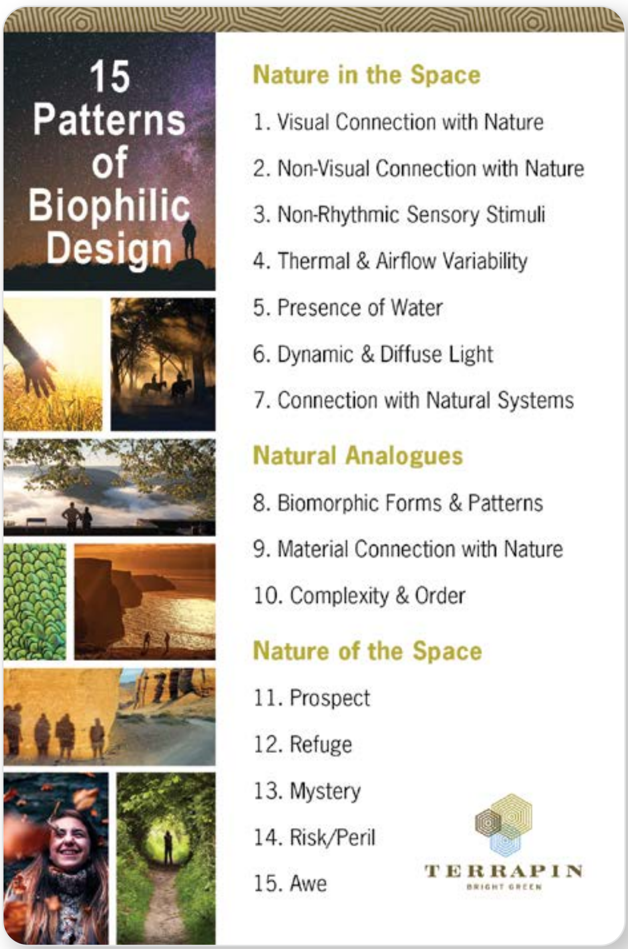

1st Edition Thanks

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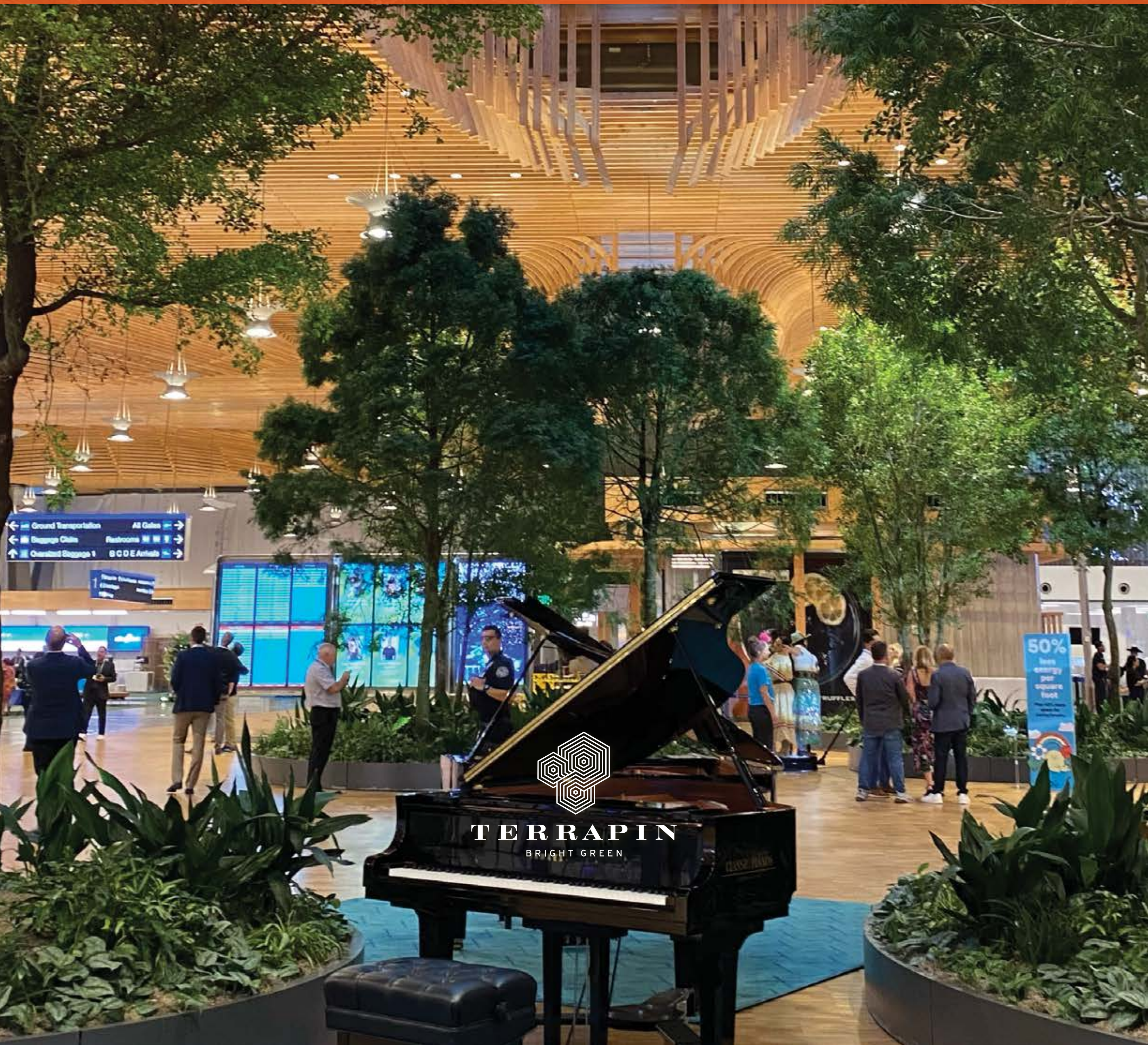
10+ Years of Design Collaboration

A special thanks to the many design firms that have collaborated with us over the last ten years to enrich the experience of their projects through biophilic design.

Man is an outdoor animal. He toils at desks and talks of ledgers and parlors and art galleries but the endurance that brought him these was developed by rude ancestors, whose claim to kinship he would scorn and whose vitality he has inherited and squandered. He is what he is by reason of countless ages of direct contact with nature.

James H. McBride, MD, 1902
Journal of the American Medical Association



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