



BIOPHILIA & HEALING ENVIRONMENTS

HEALTHY PRINCIPLES FOR DESIGNING THE BUILT WORLD

BY NIKOS A. SALINGAROS

INTRODUCTION BY
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ABSTRACT

Our biology should dictate the design of the physical settings we inhabit. As human beings, we need to connect with living structures in our environment. Designers thus face the task of better incorporating healing strategies into their work, using factors that contribute to the biophilic effect. 17th, 18th, 19th, and some 20th century architecture show the healing traits of biophilia. After that, architects ignored complex human responses to the built environment in their enthusiasm for the supposed mechanical efficiencies of the industrial approach to placemaking. Design that uses biophilia considers the inclusive, “bottom-up” processes needed to sustain our health. When ornament is coherent with the rest of a structure, it helps connect people to their environment, and creates a positive, healing atmosphere. Biophilia shows how our evolutionary heritage makes us experience buildings viscerally, and not as intellectualized abstractions. This thinking juxtaposes the focus on innovative form for its own sake with biophilic design.

“Biophilic design is not about greening our buildings or simply increasing their aesthetic appeal through inserting trees and shrubs.

Much more, it is about humanity’s place in nature, and the natural world’s place in human society...”

Stephen R. Kellert and Judith H. Heerwagen
(Kellert et al., 2008: page vii)

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INTRODUCTION

The best biophilic design—design that effectively eliminates stress and anxiety from the built environment—is achieved by maintaining thoughtful connections with nature. The surge of interest in creating spaces and places that support health and wellbeing is a sort of renaissance in design thinking for why we build buildings and cities. Sectors of society are gradually embracing biophilic design, from the more obvious health care facilities, schools, and offices, to hospitality venues and communities, to the less assuming airports and manufacturing facilities. For each sector there is often a different rationale—be it for higher productivity and sales, improved test scores, or better public health—and biophilic design has been a uniting construct for meeting these disparate end goals.

The traction biophilia has gained in these past few years is remarkable and I am optimistic about its future. However, in this nascent state, the general understanding of design opportunities is characteristically underdeveloped, frequently resulting in desultory interventions that fail to achieve effective health outcomes. While architectural history is replete with applied lessons from nature, the ongoing contradiction between what is taught and intellectualized, versus what is vernacular and visceral has had detrimental effects on the adoptability of effective biophilic design.

Terrapin has been actively engaged in keeping industry in touch with the scientific basis from which biophilic design has emerged—as a sort of pattern language that explicates lessons from nature for the benefit of human health. The hope is that with greater comprehension and contextualization of the relationships between nature and human health, more thoughtful biophilic design solutions will emerge.

Working toward this goal—best practices in biophilic design—will not surprisingly require greater mainstreaming of non-traditional industry alliances of architecture and planning with neuroscience, epidemiology, and environmental psychology, as well as with building diagnostics and human resources. Integrative design is a mantra of holistic sustainability practices—necessary but rarely truly achieved. Sustaining truly healing environments is no different. Much to the chagrin of committed practitioners of evidence-based biophilic design—like the early (and still provocative) champions of high-performance green buildings—truly biophilic environments are not achieved by way of add-on features, technologies and vegetation. Through practical design methods, mathematician Nikos A. Salingaros argues, a building's structure itself must strive to be healing.

Salingaros has been a steadfast proponent of an inclusive, bottom-up approach to biophilic design, citing that such an approach is necessary if buildings are to have a meaningful impact on human health. Salingaros has published extensively on aspects of biophilia and is well known for his compilations on complex structures and systems, *Design for a Living Planet* (Mehaffy and Salingaros, 2015) being one of the more germane systems-level perspectives to healing environments, and a favorite of mine.

This ten-part series, “Biophilia and Healing Environments,” further adds to the industry’s body of resources for identifying and developing effective biophilic design interventions. Some readers, like myself, will appreciate Salingaros’ direct and cogent explanation of human scale design, neurobiology’s preference for complex geometry, and the link between ornament and human intelligence. Salingaros breaks down the major factors that contribute to a biophilic experience into what he refers to as the “eight points of the biophilia effect”. He also introduces eight “cognitive rules for ornament” to help judge whether a form contributes to a healing environment.

The qualitative rules that Salingaros and other biophilic design practitioners have in mind are not rigid, but suggested constraints that can be satisfied in an infinite variety of ways. As such, rules like those proffered by Salingaros can serve as tools for conceptualizing a design with greater overall coherence and support of enhanced cognitive development and performance. So often industry insists upon the perfect quantitative metrics against which to measure design effectiveness, but perhaps we should instead be using rules, and the like, as contextually qualitative metrics. It is the quality of the space, as we have learned, and less so its size or quantity, to which we are viscerally responsive.

As our understanding of the constructs of biophilic design evolves, the rules and lessons from nature that best inform the design of effective healing environments will continually rise to the forefront of our design language. “Biophilia and Healing Environments” contributes to this process of understanding, inching us closer to what I hope will one day again be intuitive in practice—the best biophilic design.

Catherine O. Ryan
Terrapin Bright Green

“And if you live in a system of boxes, as most people do, you can barely struggle to achieve an effective life.”

Christopher Alexander
Lecture at Berkeley,
California, 2011

“People need contact with trees and plants and water. In some way, which is hard to express, people are able to be more whole in the presence of nature, are able to go deeper into themselves, and are somehow able to draw sustaining energy from the life of plants and trees and water.”

Christopher Alexander
Pattern 173 “Garden Wall”
(Alexander et al., 1977: page 806)

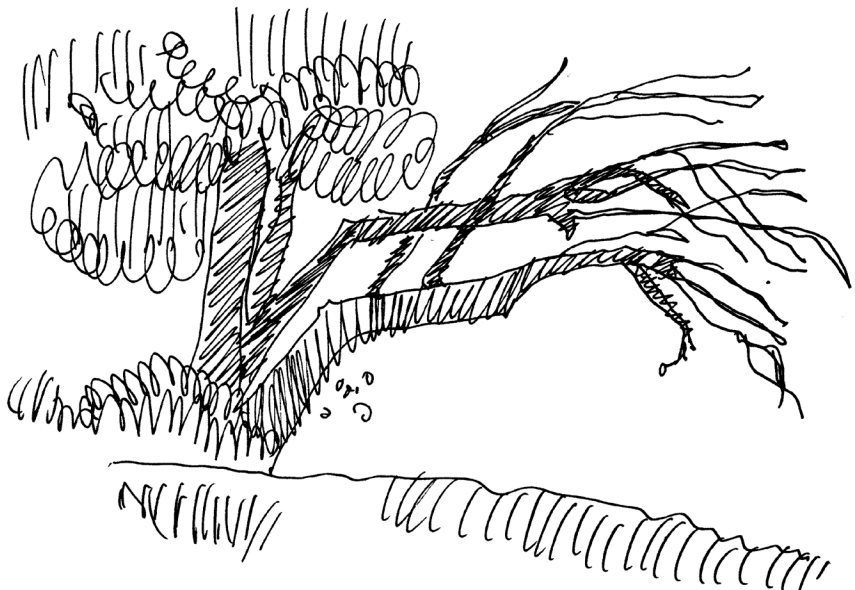
Figure 1. Geometrical characteristics of our ancestral savannah environment shaped our cognitive system.

1. WHY WE SHOULD BE LIVING IN “LIVING” HOUSES

The Biophilia Hypothesis was put forward by one of America’s greatest biologists, Edward O. Wilson. He postulated a human need to connect with living structure in our environment (Kellert *et al.*, 2008). This, Wilson argued, was neither a simple liking nor an aesthetic preference, but a physical requirement equivalent to our need for air, water, and food. A survey of what we prefer to have in our home environment includes greenery in the immediate outdoors, indoor plants, pets, and contact with other people. We prove the importance of this biophilic effect with each step we take to shape our environment so that it nourishes us.

But aside from bringing live beings into our living spaces, there are also aspects to the design of buildings that make them attractive and life-enhancing. These factors arise no less surely from biophilia — the word literally means love of life — than does having plants and animals around. While other factors play a role, key elements of successful buildings (from the user’s point of view, not the architect’s) can be ascribed to biophilia. Judging exclusively by indicators of human health, and ignoring the fame of the architect and the media hype for certain fashions, we can identify buildings by both named and anonymous architects that offer the greatest sense of well-being for their users. The structure of those buildings triggers a healing process in our own bodies, so that we consequently wish to experience such buildings as often as possible.

Two parallel strands of conjecture help to explain the biophilic effect. One source of the biophilic instinct is thought to come from inherited memory, from our evolution and development in the environment of the savannah long ago. The savannah consists of open grassland, clumps of bushes, scattered trees, plenty of sunlight, bodies of water, grazing animals, etc. Our ancestors relied on information gleaned from those characteristics to hone their capacity for survival, to learn to intuit the presence of a tiger. We first became human in that setting, genetically encoding its geometrical



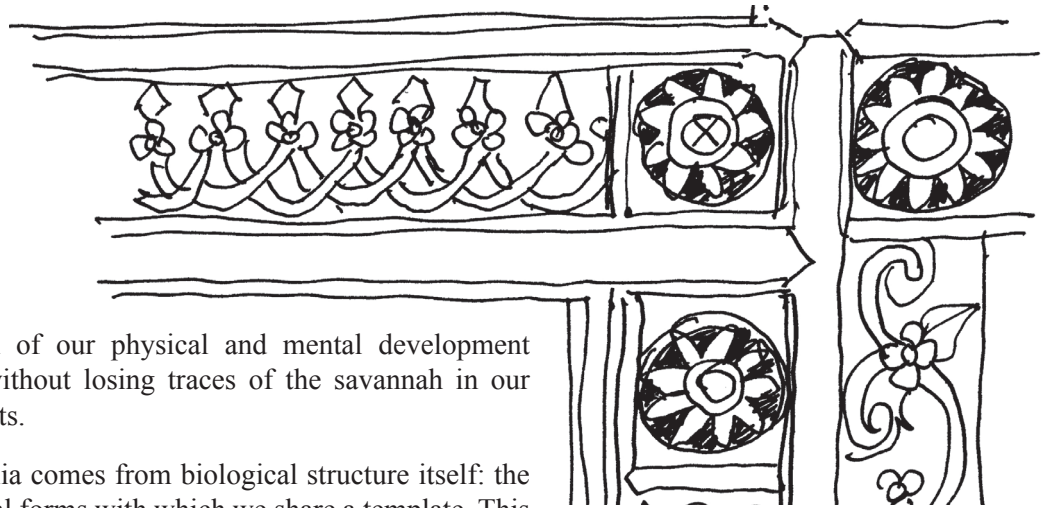


Figure 2. Carved ornamental doorframe. While inspired by natural forms, the human mind has introduced organization and symmetries.

qualities. The sophistication of our physical and mental development progressed over millennia without losing traces of the savannah in our inherited memory and instincts.

The second source of biophilia comes from biological structure itself: the geometrical rules of biological forms with which we share a template. This structure is believed to elicit a general response in humans of recognizable “kinship” that cuts across the divide between living and inanimate form. Manmade structures with basic properties in common with our own bodies resonate, “strumming the strings” of our biophilia. Mechanisms of living structure are either the same, or they parallel the basic organization of biological systems. Biophilia, therefore, mixes the geometrical properties and elements of landscape with complex structures found in — and common to — all living forms.

Human sensory organs and systems evolved to respond to natural geometries, which are characterized by colors, fractals, scaling, and complex symmetries. Fine-tuned to distinguish positive aspects (food, friends, mates) from negative aspects (threats) in the environment, our perceptual systems generate positive emotions from surroundings that resonate with our biophilic instincts. For example, experiments in hospitals show much faster post-operative healing and reduced need for pain medication in patients with rooms whose windows look out on trees (Mehaffy & Salingaros, 2015). Hospitals and sanatoria reaching back to ancient Greece were set in natural surroundings, and part of successful medical treatment once typically included time spent in gardens and under trees.

At the same time, we constantly suffer the inverse effect of our biophilia. Our bodies signal the absence of natural geometries and structural balance with anxiety and illness. Evidence accumulates to support the traditional wisdom that warns of social and mental decline in surroundings deprived of natural features, geometrical stability, and ornamental variety — minimalist environments offering scant nutrition for our biophilic instinct. Since the advent of the industrial age, city dwellers who could afford it escaped in the summer to enjoy the health benefits of the countryside.

2. WHAT DO LIGHT, COLOR, GRAVITY AND FRACTALS HAVE TO DO WITH OUR WELL-BEING?

Here are the major factors that contribute to the biophilic effect experienced by human beings. Strictly speaking, our craving for natural light is properly termed “photophilia”, and that for natural environments “topophilia”. Nevertheless, it is useful to include all of these physiological responses under the broader term *biophilia* (Mehaffy & Salingaros, 2015; Ryan *et al.*, 2014).

1. LIGHT

We seek natural light, preferably from different angles so that shadows do not diminish our stereoscopic vision, necessary to form three-dimensional imagery and depth perception. Natural light is not merely essential to perceive and then to evaluate our surroundings: our skin requires sunlight in order to manufacture vitamin D, crucial to our metabolism. We possess two organs that require sunlight: our eyes and our skin. Our circadian rhythms (our instinctual perception of time, our “internal clocks”) are regulated by sunlight on the eye and skin, which controls our sleep cycle via melatonin secretion. Whenever our circadian rhythms are disturbed (as in jet lag), our bodies are chronically fatigued and cannot function properly. We require sunlight to re-set them.

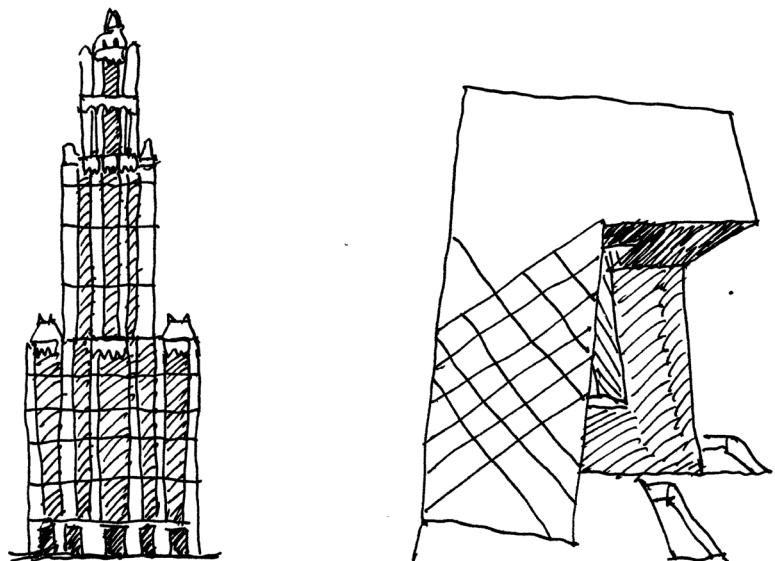
2. COLOR

Pigmentation of partial intensity but overall harmony generates a healthy effect. Color perception is one of our senses (including receptors in our eyes and processing pathways in our brain) that links directly with our emotions. Humans evolved in natural light that ranges in coloration from red to orange to blue, depending upon the time of day. This describes the hue of incident light. The color of plants, animals, rocks, etc., formed our preference of colors in the environment. We experience color both in the

TABLE 2.1. EIGHT POINTS OF THE BIOPHILIC EFFECT

1. LIGHT
2. COLOR
3. GRAVITY
4. FRACTALS
5. CURVES
6. DETAIL
7. WATER
8. LIFE

Figure 3. Left: Balanced form reinforces tectonic stability, Woolworth Building, New York City, 1913, 792 feet or 241 meters. Right: Cantilevered form generates anxiety, Giant Underpants Building, Beijing, 2008, 768 feet or 234 meters.



transmitted quality of light and as reflected from pigmented surfaces. The psychological effects of color run deep, and they are used (and abused) extensively by the advertising industry. Interior designers employ colors and color harmonies to affect people's psychological mood. Gray, colorless surroundings are associated by our mind's eye with illness, decomposition, and death (Salingaros, 2006: Chapter 4).

3. GRAVITY

We feel and relate to balance through gravity. Plants and animals grow in gravity, thus their forms show an exquisite vertical balance. In natural structures, the heavier parts are on the bottom and the lighter parts are on top. Our brain automatically computes the gravitational balance of forms that surround us. All objects in nature exist in gravitational equilibrium, and this informs our mental reverence for stable structures. Forced perspective — where scale is deliberately shrunk as your gaze rises — is used in traditional architecture and stage sets. This exaggerated perspective “reassures” our body of the gravitational balance around us, reducing stress. Conversely, its imbalance causes anxiety and even nausea. Our balance mechanism is centered in our inner ear. For this reason, nausea is triggered exactly the same way in the case of imbalance (perceived loss of equilibrium) as in the case of the body poisoned by an ingestion of toxins.

4. FRACTALS

A fractal encodes geometrical structure on many different linked levels: it has no preferred scale, hence any structure is scale-free. Fern leaves and cauliflowers are examples. Many scales are present in a fractal, with complex structure showing at any magnification. A fractal contains well-defined subdivisions of structure in an ordered hierarchy of scales, from the large size down to the size of its details. Much of living organic tissue is fractal — for example, the nervous system, the circulatory system, and the lung's system of branching air passages. We recognize and respond positively to fractal structures because our own bodies have these in common with other animals and plants. This similarity links us cognitively to structures that follow the same geometrical principles, such as landscapes, trees, bushes, and animals. On the other hand, we react poorly to structures that are not fractal: smooth or shiny objects or surroundings create alarm. This discomfort occurs because their minimalism contradicts the fractal structures and patterns we are used to experiencing in natural environments (Salingaros, 2012a).

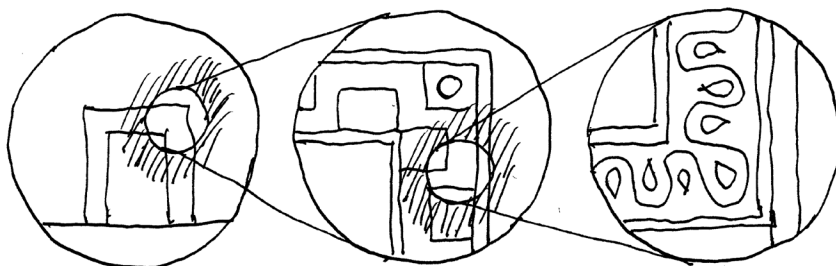


Figure 4. Fractals show structure at every successive magnification. The more perfect fractals are self-similar.

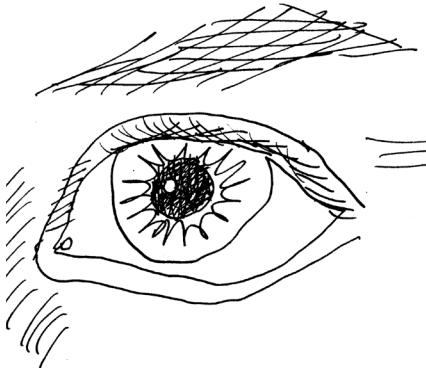


Figure 5. Complex details (implying that the details themselves have substructure) are vital for meaningful information exchange.

5. CURVES

Curved forms are found everywhere in nature, where it is in fact difficult to find a straight line. Again, curves arise from the biological structure of animals and plants, and also from natural inanimate environments where matter is shaped by tectonic forces. Smooth curves are mathematically at odds with angled (“broken”) types of fractal such as are found in trees and in the weathered patterns of natural materials. The natural environment exhibits fractal or curved forms, or a combination. We do not expect straight lines or right angles in nature. Since our neurological-response mechanisms are hard-wired, we obtain emotional pleasure from curves that possess a natural balance through symmetry. Curves in the environment that are gravitationally unbalanced, however, can be unsettling.

6. DETAIL

On the most intimate scale — at arm’s length and closer — highly organized complex detail is visible and touchable throughout nature. Our sense of touch requires that we be near a surface or structure so as to recover information from the most detailed levels of scale. We focus on the smallest detail, sharply defined natural structures and textures such as veins in stone (fossilized animals and plants), wooden grain, branches and leaves in trees, etc. We expect to find the same sort of complex structural detail in an artificial environment, since our perceptual mechanisms are finely tuned to process such signals. In fact, look at the underside of a leaf and you see its veins display, at the smallest visible level, a fractal network resembling an irregular urban street grid. Natural materials emerge as fractals, and provide interesting organic information at increasingly minute distance, heightened by our ability to touch them. To communicate with animals (including humans), we focus on their eyes, pupils, lips, and nostrils (and the ears of cats and dogs). “Subliminal communication” when face-to-face with another human depends upon subtle anatomical cues we receive from such details. Meaningful response to other life occurs through tiny details, predisposing us to focus on those. We transfer to the built environment our inclination to grant importance to small details. We feel cut off from this mechanism when we experience architectural styles that largely lack detail or have detail that exists in randomly textured form, chaotic, and intuitively indecipherable.

7. WATER

The presence of water can be healing. Human beings love to see water, and even better, hear it and feel it. Perhaps the need to be close to water is a reassurance that we have enough water to drink, because without water we cannot survive. It could be a vestige of the streams and lakes in our ancestral environment. Strict necessity does not, however, explain the joy of visiting the salty sea. People the world over go to the beach, and enjoy a promenade along the waterfront. A vast worldwide tourist industry is driven by vacations on the coastline, and the obvious pleasure of voyages in water-going vessels, from sailboats to cruise ships. (While not biophilia in the direct sense of attraction to living forms, the effect is included in this group by strength of parallel.)

8. LIFE

Actual and intimate contact with living forms nourishes us. This is the most obvious meaning of biophilia. We crave the companionship of plants, animals, and other humans. This is not among the features of a building *per se*, but serves to encourage the building user to interact with the natural environment. For example, enclosing a courtyard garden, or surrounding a building with intimately interwoven trees and shrubs, provides immediate access to nature. It is not merely decorative. The biophilic effect nurtures and is nurtured by such simple acts as bringing a potted plant indoors. This has nothing to do with a building's structure or design itself — except that buildings that shut off fresh air and light inhibit the survival of plants. (Humans thus entrapped might well also be wary.)

These eight descriptions show how the biophilic effect can be applied to help design buildings conducive to health. Biophilia reflects natural intuitive response in humans to their environment. It is sometimes confused with what might be called biomimicry, which applies inert copies of natural structures to a building's skin. A building that features, say, ranks of identical shards in its facade might resemble a faddish conception of fractals, but this will not improve the building's influence on the well-being of its users. To impart a healing effect, an architect must apply basic guidelines for generating specific biophilic elements, and not just mimic some organic form. That's not enough. Taking the above eight points as a rough design checklist for biophilic properties, we can generate criteria for evaluating the health-inducing aspects of architecture, built and unbuilt.

3. WHAT KIND OF DESIGN TRIGGERS HEALING?

Overwhelming evidence shows that biophilic environments, both natural and artificial, exert a healing effect on the human body. For example, significant health benefits are measured in neighborhoods with street trees (Kardan *et al.*, 2015). This healing process also acts by association on the designer's own body when he or she is creating biophilic design. The biophilic effect takes place here at the closest, most intimate scale, making the designer healthier through the feedback response that arises during the act of creation or making. The opposite effect is also predictable: designing and building *biophobic* structures is pathological.

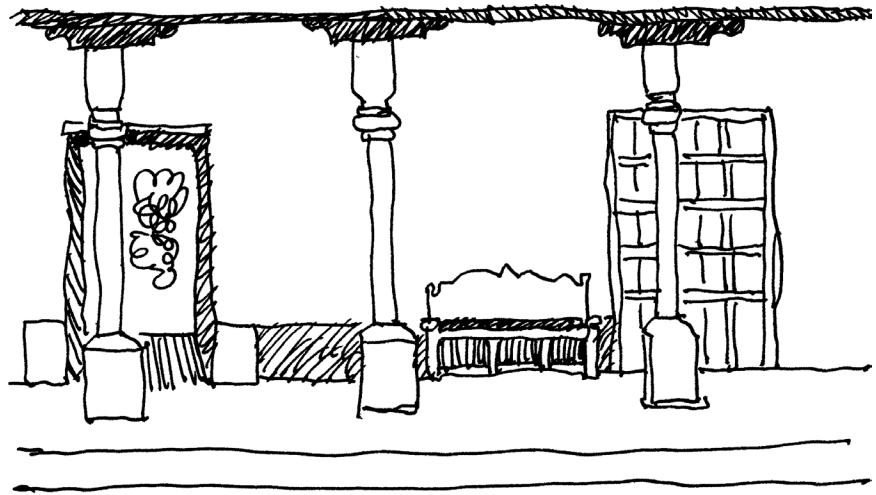


Figure 6. Biophilic design is better for both architect and user, because the creation of living structure turns out to be emotionally nourishing.

Decades of formalistic, computerized design practices have left architects in a poor position to create healing environments. Digital systems such as CAD (computer-aided design) have sidelined the traditional roles of immediate feeling and mutually adaptive response in generating architecture. Biophilic qualities long intrinsic to design practice, handed down over generations, evolving their use over time, have become irrelevant to the discipline. By bringing those living qualities back into architecture's toolbox, we can better incorporate healing strategies. We accomplish this with our own direct emotional responses, which must be reintroduced into today's practice. The architectural community faces the difficult task of teaching itself to perceive and to treasure the healing instinct (Salingaros, 2013: Chapter 16).

Early 20th century architects decided to consciously ignore biophilic qualities in the built environment. Practitioners long had a sense of these qualities through their intuition and older design traditions. All architects had used intuition — feelings — as a basis for critical judgment. Introducing ideological design principles that rejected intuition as a criterion to evaluate form, space, and surface changed the direction of architecture. It opened the door to an unprecedented vocabulary of non-adaptive forms — heralding a truly new sense of innovation. However exciting, the equation of novelty and creativity has eroded the adaptivity of design to the environment — dubious progress in architecture at a steep cost in human health.

Christopher Alexander observed that “making wholeness heals the maker” (Alexander, 2001-2005; Salingaros, 2012b). The act of creating biophilic structure in our environment is healing for the architect, independently of the users’ experience of the structure after it is built. For the designer, the feeling of accomplishment, satisfaction, and joy are healing. If the structure itself arises from processes that reflect biophilic adaptivity, then the acts of conceiving an idea for a building, drawing it on paper, thinking it through, planning its construction and actually building it are equally healing for the designer and all involved. The biophilia of the structure generates a healthy response along the entire scaffolding of small mental and physical acts that add up to and constitute the completed architectural project.

Nevertheless, few conventional architects today practice biophilic design, thus missing out on this nourishing feedback. Why not? I believe Alexander, in his concentration on the intuitive generosity of building places for people, neglected the dark side of human nature, where satisfaction is also gained from destroying living structure (Buckels *et al.*, 2013; 2014). This destructive and even self-destructive side is a matter for psychology to consider. We must await research to describe the workings of this darker side of design [for background, see the famous 1982 debate between Alexander and Peter Eisenman (2004) and Chapter 32 of (Salingaros, 2013)].

Note that cruelty is something practiced only on living organisms: one cannot be cruel to a rock. *Biophobic* design is the opposite of biophilic design. It can be interpreted as an act of cruelty. The victim here is not a nail or the board it is being pounded into, nor is the hammer a villain; the victims are the people who eventually must experience biophobic structures. When architects derive pleasure from the practice of creating places with little or no human vitality or healthy feedback, either to users or the architects themselves, we raise alarming questions of psychological motivation.

For most architects, it may be assumed that biophobic design springs less from such dark motives than from architects’ immersion in a design culture

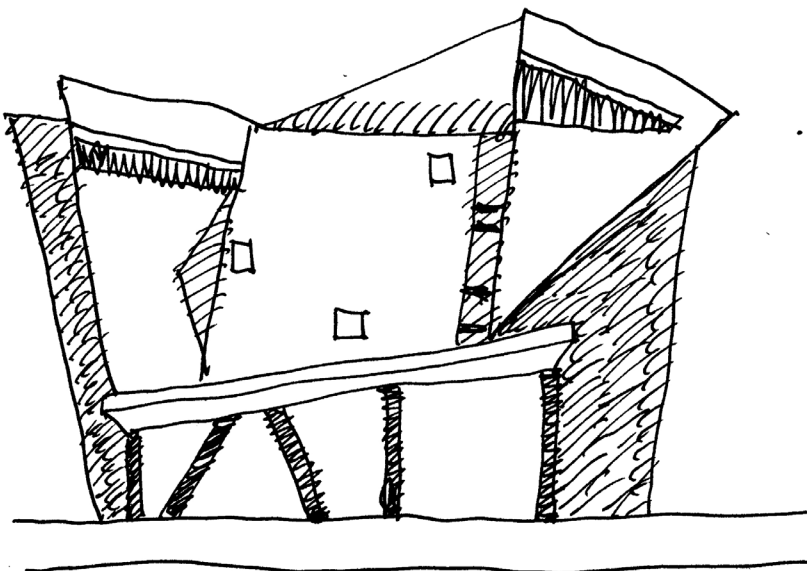


Figure 7. Did the architect of this building derive pleasure while designing it? If yes, was it a healthy or destructive pleasure?

that largely rejected biophilic design in the field long ago. Biophobia is not in architecture's DNA — science argues that biophilia is — but design education, advocacy, and practice today inculcate biophobia into the mindset and repertoire of designers with a depressing effectiveness.

Design as a practice holds out the promise of pleasure. How do architects who reject living structure get their emotional satisfaction from design? One possible source is the satisfaction gained through power. A designer gets an adrenaline rush from shaping the built environment, and enjoys playing with form at will, often without any restrictions. The more a design expresses a designer's personal will, the stronger the excitement. Top practitioners can indulge themselves freely and expect great rewards.

This is freedom without responsibility. The license to create without any heed for the consequences to users, however it may please some designers, must not be allowed to remain an intrinsic and rewarding attribute of architecture.

Biophobia is explained further in the APPENDIX.

4. MODERN ARCHITECTURE TELLS AN INCOMPLETE STORY

The extraordinary success of many 20th and 21st Century buildings with organic shapes has arisen almost entirely from biophilia. I brush aside their architects' own explanations crediting technical aspects of the design process — such as paper crumpling, or using a particular design software — which have little to do with a building's effect on users. It is safe to say that their clients paid for them and the juries of design competitions chose them because they felt a strong attraction to the original drawings. The finished buildings tend to lack the full spectrum of biophilic qualities, however, and so cannot be considered an unqualified success.

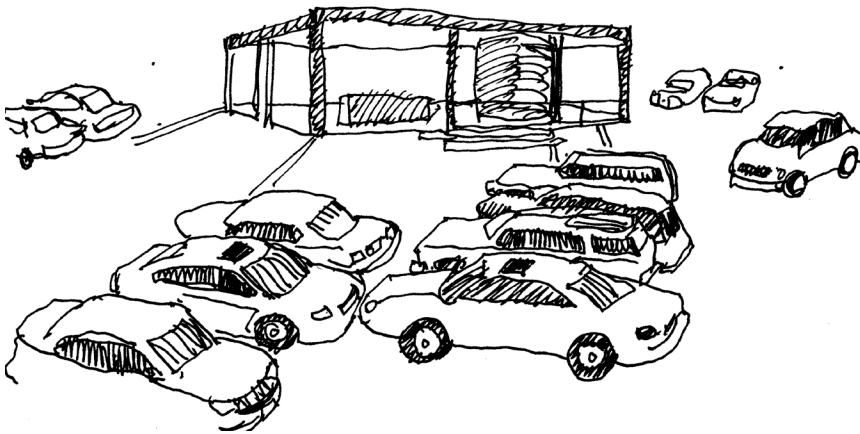


Figure 8. Philip Johnson's Glass House moved to a parking lot has no biophilic properties.

The biophilic qualities that make a building immediately attractive are perceived very differently at various distances. This can create a problem in buildings whose scaling relationships work against biophilia. A building could be biophilic as seen from a distance but not close up, or vice versa. Or, the building could incorporate no biophilic elements itself; yet steal biophilic credit from its natural surroundings. Famous examples of the latter are the Glass House (1949), by Philip Johnson, and the Farnsworth House (1945-1951) by Ludwig Mies van der Rohe, two transparent houses set in the woods.

In other cases, buildings may be biophilic close up. Biophilia is triggered by extensive use of polished stone, as in the marble of the Stoclet Palace (1905-1911), in Brussels, by Josef Hoffmann, and the marble, travertine, and red onyx of the German Pavilion (1929), also by Mies, at the International Exhibition in Barcelona. The large scale of those buildings, though, is not biophilic but severely unnatural in their geometry. Both use pools of water to soften stark exteriors — one factor of biophilic design (Kellert *et al.*, 2008: Chapter 4). Their architects evidently understood the factors contributing to biophilia, even as they sought to break their designs away from it. Incompatible forces are at play in the work of these and other architects during this early modernist period.

The desire to embellish arises naturally when designing one's own surroundings at an intimate scale. Bottom-up or generative design philosophies satisfy this impulse. Smaller scales represent ornament



Figure 9. Nikos at the Barcelona Pavilion in 2012

and elements of which ornament is composed. Ornament arises more naturally from bottom up, but using a rich form language can ensure that coherence is achieved from top down as well (Salingaros, 2006: Chapter 11). But such coherence is difficult if not impossible when top-down design employs smooth surfaces without adornment, sheer glass curtain walls, and sharply-edged windows and doors without frames. This is not an argument against top-down design *per se*, but against stylistic choices that omit the smaller scales. Top down fails when it omits small scale; bottom up never makes that choice.

Regardless of style, human health and comfort rely on the smaller scales, which allow the mind to register the crucial presence or absence of a complete scaling hierarchy in architecture.

The 20th century saw a massive and unprecedented application of industrial typologies and materials, imposing top-down styles that changed the way architecture and the city looked and felt worldwide. Proponents of the *International Style* considered it “rational”, because it was a product of an internal logic of clean, rectangular geometries [but see (Mehaffy & Salingaros, 2015: Chapter 3 & Appendix 1)]. This design philosophy’s driving force relies on drastic simplification and industrial materials in their raw form. Small scales are largely eliminated and ornament largely forbidden. Most people today identify “rational” design with simplistic geometries in a formal framework.

Top-down design combined with industrial materials merely omits complex structures on the small and intermediate scales. How can we adapt to human sensibilities if we don't work with the available tectonic scales at all human dimensions? The answer is clear, however uncomfortable it may make some readers. The fundamental contradiction among the *International Style*, biophilia, and local adaptive architectures has not been resolved and cannot be. The reason is obvious: a generic non-biophilic style supposedly applicable everywhere cannot simultaneously adapt either to human nature or to local conditions. The latter vary widely around the globe. Human nature does not.

In their enthusiasm for the sheer power of the supposed mechanical efficiencies of the industrial approach to placemaking, architects ignored complex human responses to the built environment. Many architects still believe this was a valid choice, but it contradicts human biology.

Perceiving this, some architects ditched the *International Style*, proposing a re-validation of the traditional urban fabric and building typologies of their native lands. They discovered how to merge top-down design with biophilic adaptivity. Rediscovering the traditional city as a textbook of stored adaptive solutions that can be drawn upon for contemporary architecture opened the door to more innovative adaptive design.

5. WHAT DO HISTORIC BUILDINGS SAY ABOUT OUR CONNECTION TO THE NATURAL WORLD?

Buildings throughout history and in all regions of the world employ the healing effect of biophilia. Sir Banister Fletcher's *A History of Architecture* (1996) shows examples of how every building up until the 20th Century partakes of biophilia's healing effect, although that may not be the only explanation for their success. Beginning in the 20th Century, architecture abandons biophilia or uses it selectively, and even in those cases, not always successfully. Nevertheless, some buildings from the early 20th Century onward employ organic forms in a biophilic manner, and explicitly biophilic elements have been used in recent decades.

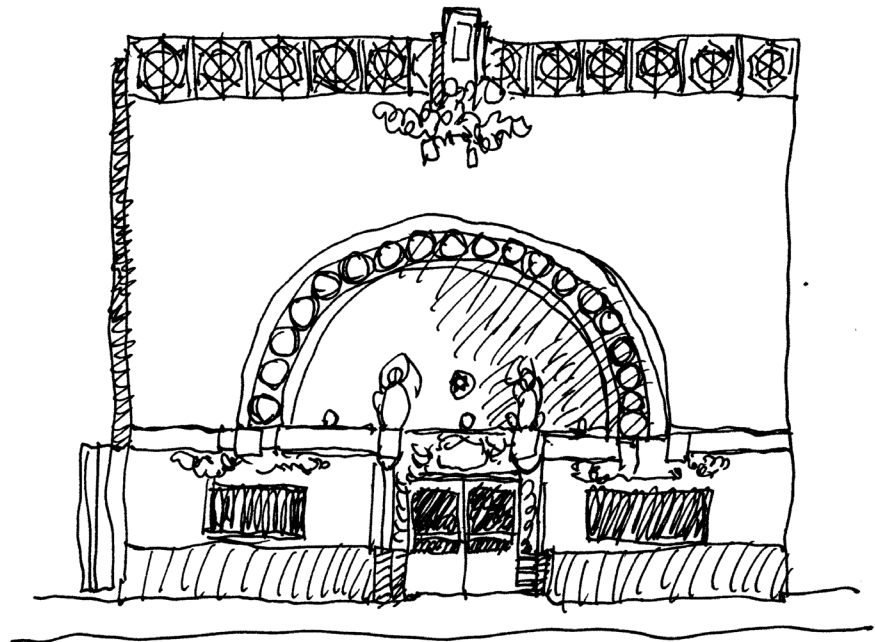
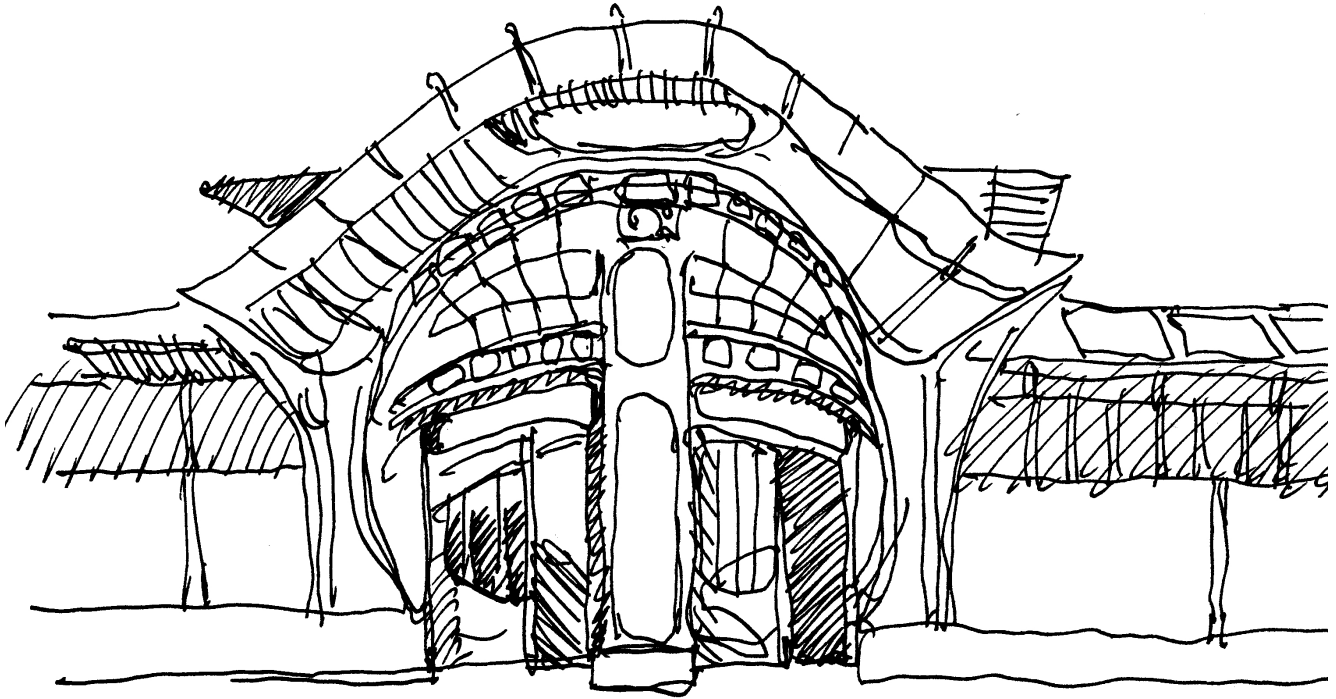


Figure 10. One of Louis Sullivan's last masterpieces: the People's Bank in Sidney, Ohio, 1918.

Let's examine some buildings from the late 19th and early 20th centuries to evaluate their biophilic content. For sheer exuberance, those of Louis Sullivan are unparalleled in their combined use of fractals and curves. One of my favorites is Chicago's Carson, Pirie, Scott and Company Building, erected in 1899, with its florid entrance. Equally fractal but even more curved are the Art Nouveau buildings from the same period, mainly in Europe, which include masterpieces by Victor Horta in Belgium, including his 1898 atelier, later Musée Horta, in Brussels, and Hector Guimard in France (entrances to the Paris Metro, built from 1900 to 1912).

These latter three architects applied new building techniques that employed industrial materials toward the end of the same 19th Century whose beginning ushered in the era of industrialization. This was not hand-made Medieval or Renaissance construction (which might be dismissed today as impractical) but early 20th Century industrial manufacturing using terracotta panels, cast iron, and glass panels. So "industrial" does not necessarily mean exposed steel beams, glass curtain walls, and Brutalist concrete!



Grand and opulent 17th, 18th, and 19th century formal architecture relied on curvature and ornamentation to trigger the healing effect. A fine example of this reliance is the Paris Opera House (1861-1875) by Charles Garnier. Such buildings are harmonious *despite* the richness of their various contributing structures, colors, and details. Some buildings from this period overdo it, perhaps, with visual and structural complexity whose incoherence is without parallel in the perfectly organized complexity of nature. We react to those examples, whose architects did not fully grasp the need for informational coherence, with a feeling of being overstuffed.

Figure 11. Place de la Bastille Metro Station by Hector Guimard, 1900, willfully destroyed by the French Government in 1962.

While such observations may be interesting in a “Great Buildings” survey course, they hardly represent world architecture. The vast majority of construction in the world has always been and remains a bottom-up activity, carried out not by great architects hired by wealthy clients but by users themselves erecting the structures they need. Their methods partake of design solutions embedded in the collective memory of generations of builders either handed down or rediscovered by trial and error. Such methods of vernacular design and construction, it turns out, are both adaptive and biophilic.

Until recent decades, most builders by habit made use of local materials and low-tech energy-saving measures dictated by tight budgets. The vernacular architectures of people around the world go unmentioned in the “Great Buildings” courses. Building types have evolved through the centuries, with most changes focusing on the scales corresponding to the dimensions of the human body. Builders’ top priority had long been to achieve a high quality of life for themselves or clients by channeling architecture’s ability, abandoned in the past century, to harmonize human emotions. Working at the smaller scales that relate best to human comfort and healing, bottom-up



Figure 12. Vernacular architecture is biophilic almost without exception.

vernacular design applies neurobiology's preference for complex geometry. For those who care to look, we see an almost unimaginable richness and variety of very different buildings and urban spaces that share a common biophilic goal. The advantages of biophilia are most reliably achieved through the nature-friendly, hands-on, practical design methods that eschew the abstract and formal prototypes normally used by most architects today.

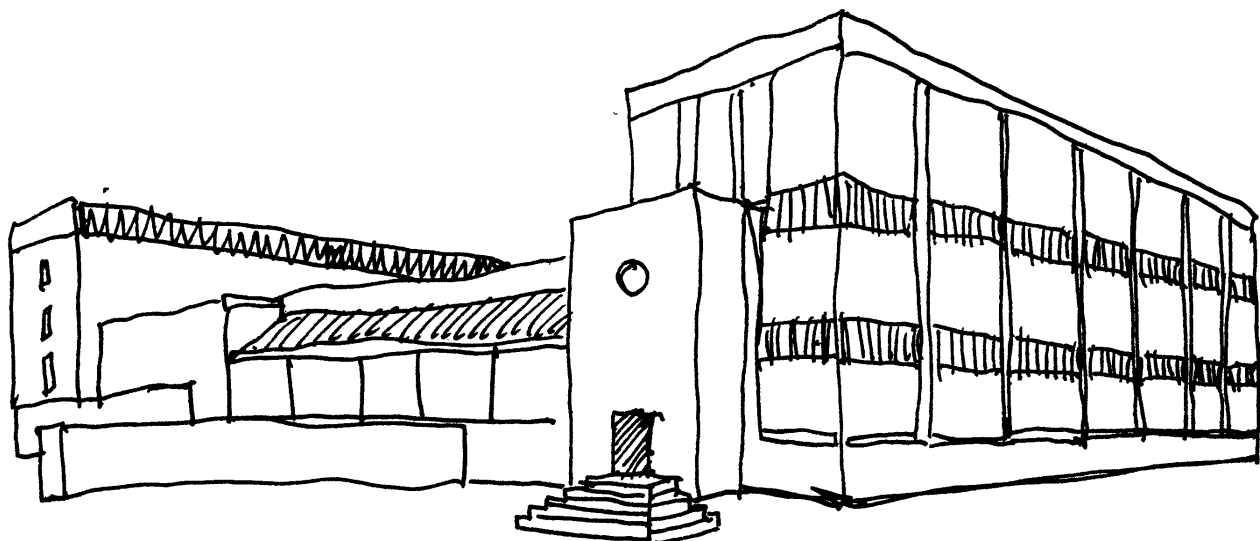
6. THE GROWING DEMAND FOR SPACES THAT CONSIDER OUR HEALTH

Our emotions control a good deal of how we ward off disease. The new discipline of psychoneuroimmunology is learning more about how our nervous system affects our immune system, hence our ability to heal. Tinkering with our individual sensibilities is not a substitute for medical treatment, of course, but rather seeks to improve the effectiveness of treatment by boosting it with endogenous healing mechanisms. With stress-induced and autoimmune diseases, the relative importance of environmental factors increases significantly. As a result, much traditional or “native” doctoring practice using the environment is now getting more attention in mainstream health care.

Evidence both from scientific sources and from traditional wisdom is giving rise to a healthier environment. Re-connecting humans with their surroundings applies the special geometry of nature to improve mental and physical nourishment. This is how biophilia works. The aim is to lower the stresses on the human body, helping its built-in defenses to fight illness and to promote healing. For most of history, medicine took the environment seriously as a factor in health and healing. Alas, the environment got ignored after the industrialized world adopted increasingly technological processes. Health care focused ever more narrowly on direct intervention via drugs, surgery, etc. This approach is now seen to have its limitations.

A healing environment arises when human beings draw from the complexity of nature, and conceive of themselves as in touch with their inner feelings and emotions. People are increasingly demanding environments that lower stress: living and working spaces that act to keep us healthy. Architects can find design tools to help achieve this goal only by looking beyond mainstream architecture, which buys into the same overly technological worldview as conventional, intervention-focused medicine today. The groundwork for these tools has been done largely by scientists — in

Figure 13. The Fagus shoe last factory in Alfeld, Germany, is the prototype for thousands of hospitals and schools around the world. Its adoption as a universal typology could be attributable to the increased natural light compared to most 19C buildings — one factor of Biophilia. Designed by Walter Gropius and Adolf Meyer, 1913.



particular by architectural theorist and practitioner Christopher Alexander and his collaborators (Alexander, 2001-2005; Mehaffy & Salingaros, 2015).

The healing effect of biophilia in architecture can be explained largely through precise and measurable geometric properties (Alexander, 2001-2005; Kellert *et al.*, 2008; Mehaffy & Salingaros, 2015; Salingaros, 2013). As more architects jump on the biophilic design bandwagon, however, the mathematical basis of biophilia and healing environments has tended to be obscured. Much of what architects assert about biophilia in the helter-skelter race to win major commissions is either untrue or very poorly understood. (It's not enough that a designer becomes conversant with scientific terms; some understanding of science is essential.) Clients and the public are thus misled to expect some vague and mysterious vital force. Biophilia is not mystical at all, but quite specific and verifiable by the usual scientific methods.

The word biophilia is sometimes misused by architects to buttress the case for “green” aspects of otherwise non-adaptive designs. Yes, the presence of plants is therapeutic — a key property of biophilic architecture — but a building's structure itself must be healing as well if it is not to induce anxiety. The healing properties of sculptural buildings by star architects will be seen as inadequate once the lessons of biophilia are better understood. Biophilia does not mean adding “green” elements to sculptural designs in order to make them more alluring to clients. That is top-down design. Rather, biophilia means designing structures from the bottom up by infusing architecture's schema with processes parallel to those of biology to develop and reproduce. These processes heal because they reflect the ordered complexity associated with the adaptivity of natural systems. Correctly applying biophilia presupposes a desire to learn from nature. With or without shrubbery, top-down sculptural design actually impedes the workings of nature. Mixing real pieces of nature with anxiety-inducing forms and surfaces is not biophilia but schizophrenia.

Many architects believe that they can superficially copy an organic form to achieve a healing space. All that achieves is to create an abstract sculpture. Working knowledge of biophilia is sacrificed for the sake of visual novelty. The image-based design paradigm, however widely applauded by architecture critics and the global media, misunderstands biophilia and repudiates nature's role in the design process. To mimic natural forms is not to be inspired by nature. To use nature's genius to design places that are genuinely more natural, hence more healthy, is truly to be inspired by nature.

7. WHY DO WE CREATE ORNAMENT TO MIMIC NATURE?

Living in an artificial environment makes us long for nature. We make up for its lack by imbuing our surroundings with those geometric qualities found in nature (Salingaros, 2006; 2013: Chapter 19). We try to shape our immediate vicinity so that those qualities reproduce our response to natural environments. When we cannot have immediate access to plants and animals, the next best thing is to create ornament. This compulsion has nothing to do with architectural style in principle, though in practice the result can eventually define a style. (Architects who look down their noses at ornament tend also to look down their noses at style, even as their rationale for opposing ornament amounts to style.)

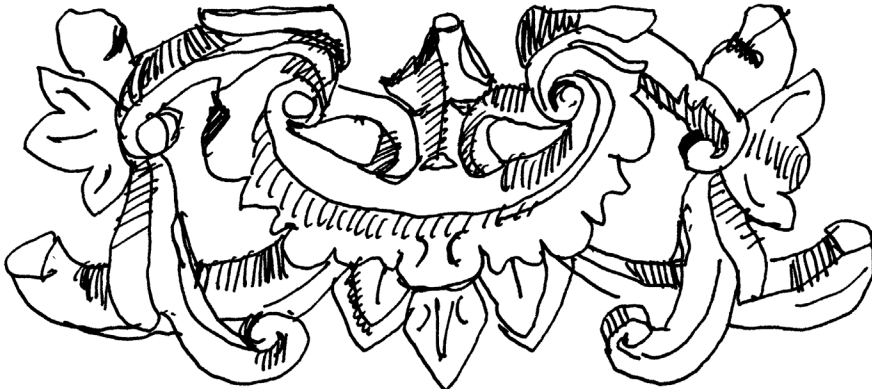


Figure 14. Ornament clearly derived from plant forms, yet with many more symmetries than in real plants.

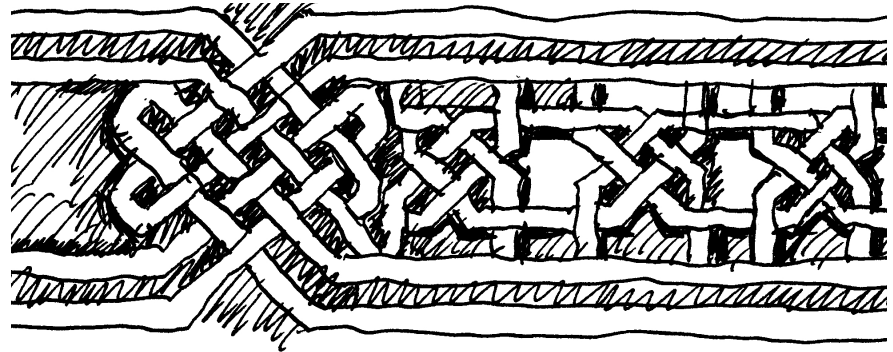
Ornament often mimics nature directly. Organic forms copied from plant life define a broad category of ornament seen throughout history and across cultures. From biophilia, natural forms have inherent qualities, reducible to a mathematical description, that induce a healing effect. Other types of ornament bear no direct resemblance to natural forms but rely instead on more abstract geometries. Here the healing effect comes not by direct biological imitation but by triggering human biology's positive emotional responses through symmetry, contrast, detail, and color (Salingaros, 2013: Chapter 16).

Ornament is simply the organization of complexity generated at the smaller scales of design (Salingaros, 2014). Humans copy the designs of nature but also impose additional ordering, symmetry, and coherence on the artifacts they make or buy. Or we begin with a naturalistic resemblance but then develop those symmetries much further. Phenomena related to how global coherence resists entropy begin to operate at larger design scales (Alexander, 2001-2005; Salingaros, 2006). The difference between ornament that looks organic and ornament that looks abstract and the reason why both contribute to biophilia need investigating. Among those writing about this topic are Ann Sussman and Justin Hollander (2015).

Christopher Alexander (2001-2005) calls "living structure" those forms and artifacts of human design that mimic the geometrical properties and organized complexity of living organisms, which human beings seem eager to create. We generate and connect to very specific abstract designs on a small scale because we feel attracted to them viscerally. Why is this so?

It's obviously linked to an evolutionary advantage that subconsciously influences what we do and how we behave. The creative urge for ornament — unacknowledged by the dominant culture — is an essential part of our instinct for generating life through our own reproduction.

Figure 15. The tremendous emotional appeal of Arab-Islamic architecture relies in large part on its abstract ornament. This example is strictly geometric and not organic, yet works in a biophilic manner.



In short, ornament is intimately linked to human intelligence. This might come as a shock to most architects trained to reject ornament on ideological grounds. Nevertheless, experiments with young animals show that complex environments dramatically increase brain size and performance on intelligence tests (Salingaros, 2013: Chapters 27 & 28). Anecdotal evidence shows similar results for human children as well, but it is ignored by architects who design schools more as a personal visual statement. The human brain is not wired to grasp the blank surfaces (Sussman & Hollander, 2015) often introduced in settings for children, as if simplicity rather than complexity — ornament and detail — were better nourishment for growing minds. It is not. This is one of many things that architects who disdain ornament don't understand.

A positive, healing response to our environment occurs whenever we perceive in our surroundings certain characteristics akin to the organized complexity of nature common to traditional ornament. Our evolution has generated in human neurophysiology an innate need to create ornament. Rules for how ornament contributes to a healing environment can be derived from understanding how the brain is wired to respond to our surroundings. Using Alexander's "Fifteen Fundamental Properties" as a starting point (Alexander, 2001-2005; Leitner, 2015; Salingaros, 2013: Chapter 19), I offer eight cognitive rules (listed in Table 2 on the following page) to judge whether a form — a building, a part of a building inside or out, or its neighborhood — is visually coherent and facilitates healing.

These rules summarize the relationship between human cognition and our creation of ornament [the interested reader will find a more detailed discussion in (Salingaros, 2006: Chapter 4)].

Different types of ornament that are coherent with the rest of a structure within a setting help connect people to their environment, and create a positive, healing feature of any building. Owner-built houses are often ornamented both on the inside and on the outside. Ornament in traditional and vernacular architecture satisfies the need for healing surfaces in spaces for living. This key phenomenon characterizes cultures all over the world. Even plain, ordinary buildings throughout history before the industrial age always used natural materials, and the healing/biophilic effect comes in part from that. For example, surfaces made of wood induce healing in stark contrast with surfaces made of aluminum, plastic, or steel (Sakuragawa *et al.*, 2005; 2007).

Notwithstanding humans' hardwired desire for ornament, it is no longer incorporated as a matter of course into the built environment. Curricula in the leading areas of design education, professional organizations that represent architects, designers and planners, and influential critics and journals that mold public opinion have imposed a virtual ban on ornament. In many quarters, the ideological rejection of ornament is an old story, no longer considered relevant — but not everyone is with the program (Mehaffy & Salingaros, 2015: Chapter 3). When such renegades mention the link between ornament and healing, most architects grow uneasy, even angry. Why? Their prejudices are being challenged. When thus affronted, they fall back on the claim that architecture is an art, and that scientific data are beside the point.

TABLE 2. COGNITIVE RULES FOR ORNAMENT.

- 1. A region of contrast, detail, or curvature is necessary.**

- 2. The center or the border should be well defined.**

- 3. Attention is drawn to symmetric ornamental elements.**

- 4. Linear continuity orders visual information.**

- 5. Symmetries and patterns organize information.**

- 6. Relating many different scales creates coherence.**

- 7. Color is indispensable for our well-being.**

- 8. We connect strongly to a coherent environment.**

8. MODERNIST MINIMALISM AND OUR RELATIONSHIP WITH OUR BUILDINGS

There is a biological reason why some structures “speak” to us in spite of cultural differences and technological changes. They have in common very specific symmetries that we are hard-wired to prefer. Ann Sussman and Justin Hollander (2015) observe that animals prioritize faces over all other patterns in their interpretation of visual cues. This is a consequence of evolution. Detecting mood changes in the expression on a cave mate’s face may be even more important than noticing the spots of a leopard moving in a field of tall grass.

Researchers have identified a figural template in the brain that picks out upright, face-like patterns in what we see. We subconsciously see faces first, including symmetric patterns resembling faces in the façades of buildings. Understanding face perception in the brain, and our highly developed intuitive ability to read subtle cues in actual faces without even realizing it, explains many things. A building of expressive design speaks to us more vividly than a building with a blank façade (or one that is twisted). Our evolutionary heritage helps us see buildings viscerally, not as intellectualized abstractions.

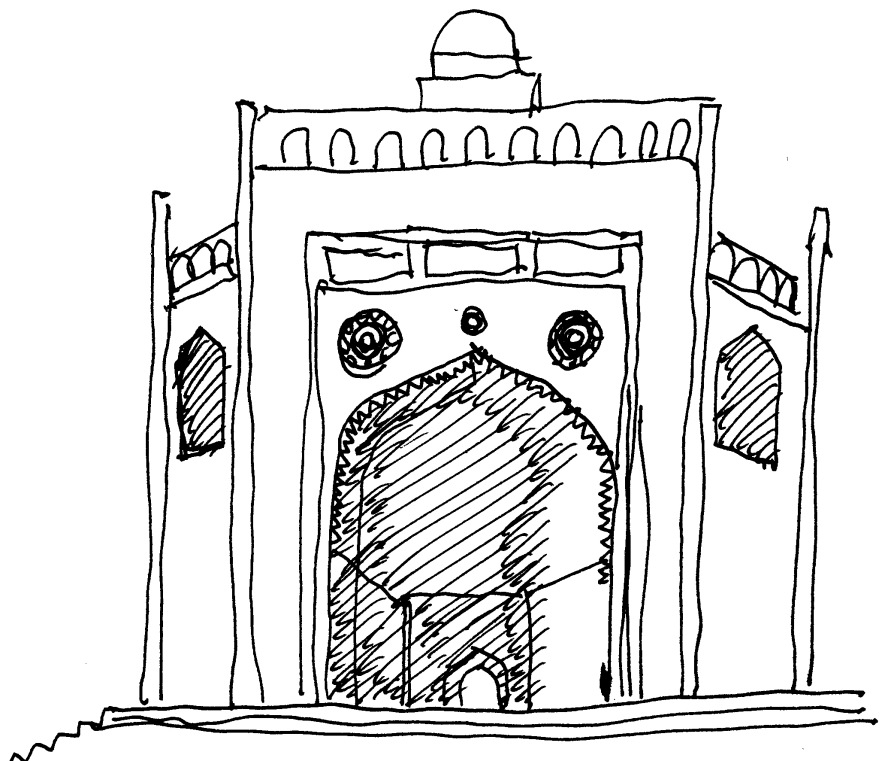


Figure 16. A monumental building with eyes, wide-open mouth, and ears. Victory Gate, Fatehpur Sikri near Delhi, India, 1571.

Mathematical information, in the form of visual patterns, ordering, symmetries, and other mental organizing systems, strengthens the coherence of the emotions in our lives. The reason is that our survival mechanisms are tuned to relax upon feeling the influence of certain patterns and symmetries characteristic of an accommodating environment, and conversely, to feel threatened by danger when those properties are absent. Contrary to what

architects are taught, the body's response to mathematical patterns is visceral: it is not intellectual — we do not “think it through” (Lakoff & Johnson, 1999; Salingeros, 2006: Chapter 7). The point is that our visceral reaction is instinctive and automatic: we can override it to superimpose a learned artistic preference on parts of our thinking, and many in our society do, but that does not change our bodily signals in any way.

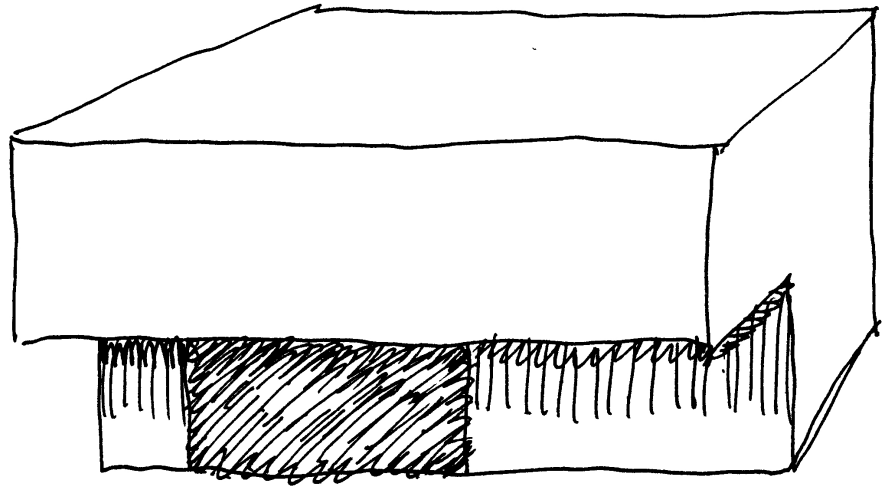
We should use this knowledge to catalogue the sources, in our natural environment, of the most positive emotional states that humans experience, then recreate them in our built environment through biophilic design. The result would be a breakthrough in architecture (Browning *et al.*, 2014). To apply biophilia and living patterns to enhance our emotional and physical health is to apply nature's lessons to enhance the creativity we bring to bear on our architecture. Traditional design practices intuitively incorporate this understanding. In scientific terms, they represent an interactive systems approach that long predated the industrially motivated effort to isolate human intellect from the feedback loop provided — for free! — by nature and the physical world.

Biophilia is the human instinct that favors living things. In *After Progress* (2015), John Michael Greer defines the antithetical phenomenon of *biophobia* as a “pervasive terror and hatred of biological existence that forms the usually unmentioned foundation for so much of contemporary culture.” Biophobia amounts to a compulsion to employ in fabricating the built environment a minimalist aesthetic of industrial materials. Since industrial materials can be shaped in any way or form, an unacknowledged ban has clearly long been in effect, limiting access to the full range of design options. Anything that bears a resemblance to biological structure is avoided. Even with the full acceptance in recent years of organic shapes in building design, their materials and surfaces still fail to express the degree of ordered complexity found in living organisms.

This is hardly accidental. It is biophobia, pure and simple. The studied and intentional rejection of biophilia requires a particular effort. That architects as social beings would purposely steer design away from a potential healing effect may be hard for some readers to accept. Leading architects are certainly not up front about it, and the average architect is barely aware of it. Most practitioners merely do their jobs as they learned in school, but their professional discourse requires obfuscation. Yet it is obvious from the built corpus of modernist architecture and its offshoots that biophobia rules.

A living environment's complexity must be extremely high to engage us viscerally, at the level of instinct. So high, in fact, that it alarms conventionally-trained designers, who prefer simplicity as more likely to enhance their sense of control as they work, and in the impact they expect their work to have. These architects avoid engaging the forms and surfaces that trigger emotions because they don't know how to control them. Rather, they seek to avoid the complexity of design that gives rise to visceral feelings; they try instead to “clean up” everything through an imposed minimalism.

Figure 17. Minimalist design appeals to individuals who are uncomfortable with living structure (biophobia). But erasing information sabotages our cognitive process.



The radical shift to implement minimalist environments was not a scientific but an ideological decision. Modern science and technology are capable of providing us, instead, with wonderfully adaptive healing environments. We can do so more easily today than at any time in human history. The commonly heard excuse that we “can’t possibly design in that manner today” reflects a *lack* of creativity, an enslavement to ideas of innovation that are a century old. The public is confused by antiquated and politically loaded slogans and imagery that identify progress with *biophobia* instead of its opposite, *biophilia* (Mehaffy & Salingeros, 2015: Chapter 3 and Appendix 1). These falsehoods have entered society’s collective understanding of modernity. But images of modernity represented in huge buildings are extremely powerful, and tenacious. A tall wall protects the architectural establishment from acknowledging the need to address the widespread ennui that is the public’s defense mechanism against a built environment that no longer reflects nature or humanity.

A regrettable historical accident — the confusion of industrial practice with industrial style — turned into a paradigm shift. The profession chose to embrace a machine aesthetic and reject the traditional insights into human nature that coupled our emotions with our surroundings. Our vital feedback loop with nature was severed. The healing effect of organized complexity was ignored. To this day, the field of design is still hung up on intellectualized approaches in which human visceral experience plays no role. Theories of design disconnect human life and emotions from any role in forming the settings where they are played out in daily life. Crude notions of mechanical efficiency — e.g., Taylorism, and Henry Ford’s assembly-line methods — compartmentalize industrial and other human systems to encourage efficiency and reduce costs. Yet these “savings” come only at the expense of subordinating our feelings and humanity in vital matters of design, isolating us humans from our own supportive emotional systems.

And so decision-makers who buy architecture today insist on twisted roofs and colliding planes, commissioning architects with a track record of sculptural imagery because they make lots of money nowadays, and also make the covers of design magazines. But the “Wow!” factor of iconic buildings today almost always has biophobic consequences. For this reason, our built environment grows increasingly unhealthy. Not coincidentally, the “wealth through biophobia” strategy of development proceeds hand-in-hand with unsustainability and the catastrophic waste of natural resources (Mehaffy & Salingaros, 2015). If this trend goes unchecked, the built environment will eventually become as unfit for human life as the natural environment seems destined to become.

9. THE IMPORTANCE OF LISTENING TO LESSONS FROM NATURE

Our lives are intimately linked to our surroundings in ways that we are not normally conscious of. Architecture that walls off the design process from natural human instinct has blinded us to that vital reality. For years we have created architecture on the basis of abstract aesthetic appeal, formal concerns, superficial or random innovation, and short-term economies. We are by now numb to the result, a defense mechanism that protects us from our own built environment. Yet we can be re-sensitized, and even “reform” the built environment through our own direct experience, designing instead based on how humans move through and react to that environment. Design must be influenced by the health and social aspects of life no less than by the aesthetic and financial aspects of architecture.

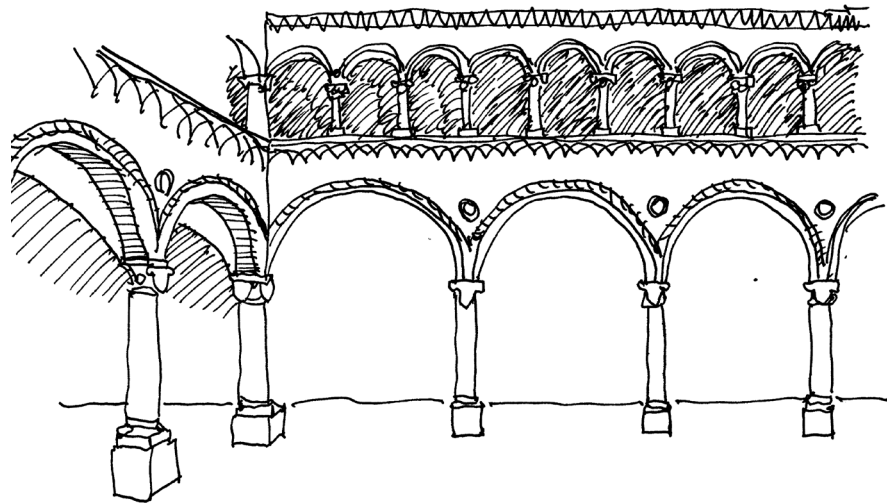


Figure 18. Hospital Maggiore Vecchio in Lodi, Italy, 1504. Without modern medicine, healing depended even more strongly upon the biophilic convalescent environment, here a typical monastic cloister.

Every form, space, structure, surface, and detail that adds to the amount of organized information in the built environment helps connect users with buildings in a healing manner. Certain precise mathematical properties of the environment produce a healing effect. To some extent, we already know the rules of biophilia (see Part 2: “*What Do Light, Color, Gravity, and Fractals Have To Do With Our Well-Being?*”). Broadening out beyond biophilia, we can choose living patterns that foster healing (Alexander *et al.*, 1977; Leitner, 2015). These socio-geometric solutions work because, long before science identified a connection, they already embodied healing mechanisms. Building methods evolved because, generation after generation, builders habitually and instinctively chose to use “best practices” identified by earlier practitioners as conducive to human wellbeing at every scale of activity in life, from walking up a set of stairs to building a city. We can easily do this again.

Adaptive design profits from mountains of accrued knowledge in architecture. A vast amount of building experience once enabled architects to intuit how people interact with the built environment. That knowledge may not be written down but is embedded in the geometries of space, surface, and detail just waiting to be deployed in ways that improve our wellbeing. Let us take care to

preserve the most wonderful built structures from our past, and not demolish them out of a misplaced aesthetic fanaticism.

A healing environment allows people to draw emotional support from their settings. It frees them to move around and interact unselfconsciously, to combine their lives with the lives of others. This psychological vitality of built space depends on the high number and the high quality of visual and intuitive interactions among elements of a space and its users. Such interactions can be classified into those among (i) the structural components themselves, and (ii) interactions of material and space with the users. Different types of symmetries and physical connections govern mutual interactions among design elements (Salingaros, 2006: Chapter 5). Physiology and psychology, in turn, govern interactions between structural elements and human beings.

Healing quality sometimes depends upon biophilia — the intuitive attraction of humans to living things — but often it arises from interaction among human beings, and between individuals or social groups and the built environment. Our visceral experience of space depends upon the geometry of artificial structures that do not necessarily resemble or relate to biological form. A complex structure with healing qualities incorporates several diverse factors to which we react. Healthy socio-geometric configurations in society rely upon our inherited intuitive response to built forms and natural settings, and generate even more healthy social interactions by encouraging their spontaneous occurrence.

Specific geometrical configurations, forms, spaces, structures, surfaces, and connective frameworks act as catalysts for human contact, generating effects through their geometry that can include healing. These special built settings encourage vibrant life in the city. By analogy, chemical catalysts also act indirectly: without them, critical interactions could never occur; chemicals mix, yet the catalyst is a fixed framework that never changes. Hence the large number of important geometrical configurations in structural design that act passively, yet are essential to foster human life and social interaction.

Historical selection driven by countless design choices — a sort of Darwinian process among architects and builders — reveals an unvarying set of configurations that trigger the biophilic effect. Traditional forms and structures evolved precisely in this manner, over time, in architecture and urbanism. The biophilic design of buildings therefore mimics the evolutionary growth and multiplication of natural organisms. The multitude of potential geometrical configurations of healthy design, over succeeding generations, “computes” adaptive solutions that are instinctively healthy and attractive to humans. Geometrical configurations that possess a healing effect represent biophilic design’s genetic material. This information was embedded over millennia into the pre-industrial built environment.

We can and do evolve such forms entirely in software. But in that kind of a procedure everything depends on the selection criteria used. With few exceptions, the selection rules are not adaptive — that is, they *are not constrained* by limitations that mimic the organized complexity of nature. Bottom-up processes that “grow” a form using a computer program work

strictly within computer memory: they are isolated from the real world and are not subject to adaptive selection. Such computational procedures, very much in vogue today, are used to produce forms that look organic but are useless as architectural solutions. The visual novelty of such forms is architectural gimmickry unrelated to natural adaptation.

The adaptive design program of Bruno Postle (2013) transcends this limitation. Using several of Christopher Alexander's living patterns as design constraints (Alexander *et al.*, 1977; Leitner, 2015), the software evolves an optimal configuration for a house, a larger building, or a cluster of houses. Simulated evolution is very slow, as millions of configurations must be considered. Since the patterns built into the program are intrinsically biophilic, the result is both biophilic and adaptive. Notably, the program automatically adapts a distinct solution to different sites and conditions.

With all the scientific advances that permit us to create healing environments today using the latest technology, we face an almost insurmountable barrier to implementation. Our minds are walled off against healthy design by conventional stereotypes of what "modernity" looks like. These stereotypes were ill-conceived a hundred years ago when a machine aesthetic was mistaken for machine efficiency. Today, designs based on human health and social vitality are typically rejected because they look "old-fashioned". Our collective consciousness still has not grasped the essential fact that built structures based on biological processes are intrinsically healing. Our brain recognizes it but our education rejects it. Architecture based on natural evolutionary procedure must necessarily inherit a certain resemblance from what came before — the design process that gave it birth. This kinship, this relationship to the past, comes from the mathematical implementation of a healing geometry. To reject that is to reject the healing effect.

From childhood, members of our industrialized society are plugged into a system of artificial visual media that replaces reality. This system has cut us off from a corrective feedback loop fed by the lessons of nature. Generations of people have grown up with a rigidly mechanistic view of the world. Being surrounded by powerful machines in the age of cheap energy and a rapidly developing technological base has given them the mistaken impression that the world is equally machine-like. Conventional design builds such a world. We have far less practice in interacting with other persons, animals, and living systems than did our ancestors.

Can architects take their focus off innovative form for its own sake, and design a more healing environment today? A new generation of conscientious designers can choose to newly embrace a moral responsibility we abandoned long ago. We can no longer in good conscience simply impose alien forms on people, because every form and every space enclosed by it changes the behavior and lives of those who have to experience them.

10. WHY WE HUG THE EDGE OF OPEN SPACES

Human biology, an artifact of our evolution, dictates much of how we behave, and offers the key to how space is actually used. Interactions with the built environment determine our behavior, often in surprising and mysterious ways. For example, people tend to avoid exposed open space and prefer to walk along its protected edges or perimeter boundaries (Salingeros, 2005: pages 32-33). Ann Sussman and Justin Hollander (2015) discuss the mechanism of thigmotaxis, defined as how organisms move in response to edge conditions: research finds that not just humans today but primitive microscopic organisms going back in evolutionary times also tend to avoid open spaces and stick to protected edges. For the human brain, the edges not only help us feel safe, they help us efficiently orient and create a ‘mental map’ of our surroundings.

Our sensory system evaluates every physical setting we inhabit, however briefly. Our neural computations do not present us with a quantitative answer, of course, but instead we get an unmistakable *feeling* in our body reacting to hormones and nerve signals. Our body’s intuitive response tells us whether the immediate environment is safe or not. The human perceptive system is exquisitely designed to detect variations in the quality of our surroundings. We adapt our behavior accordingly. A spatial configuration, translated subconsciously but very rapidly into an intuitive assessment of where we are, can be evaluated only in person, directly, using one’s senses — all of them. That is why, ultimately, our perceptual system is the only qualified and dependable judge of where we are and whether it is good for us. Such judgments cannot easily be made from pictures, architectural drawings, intellectual arguments, or others’ opinions.

Figure 19. The portico of San Luca, Bologna, Italy, built 1674-1793. This 4 kilometer-long structure consisting of 666 arches has but a single purpose: to define a sheltered path to the Church of San Luca on the hill.

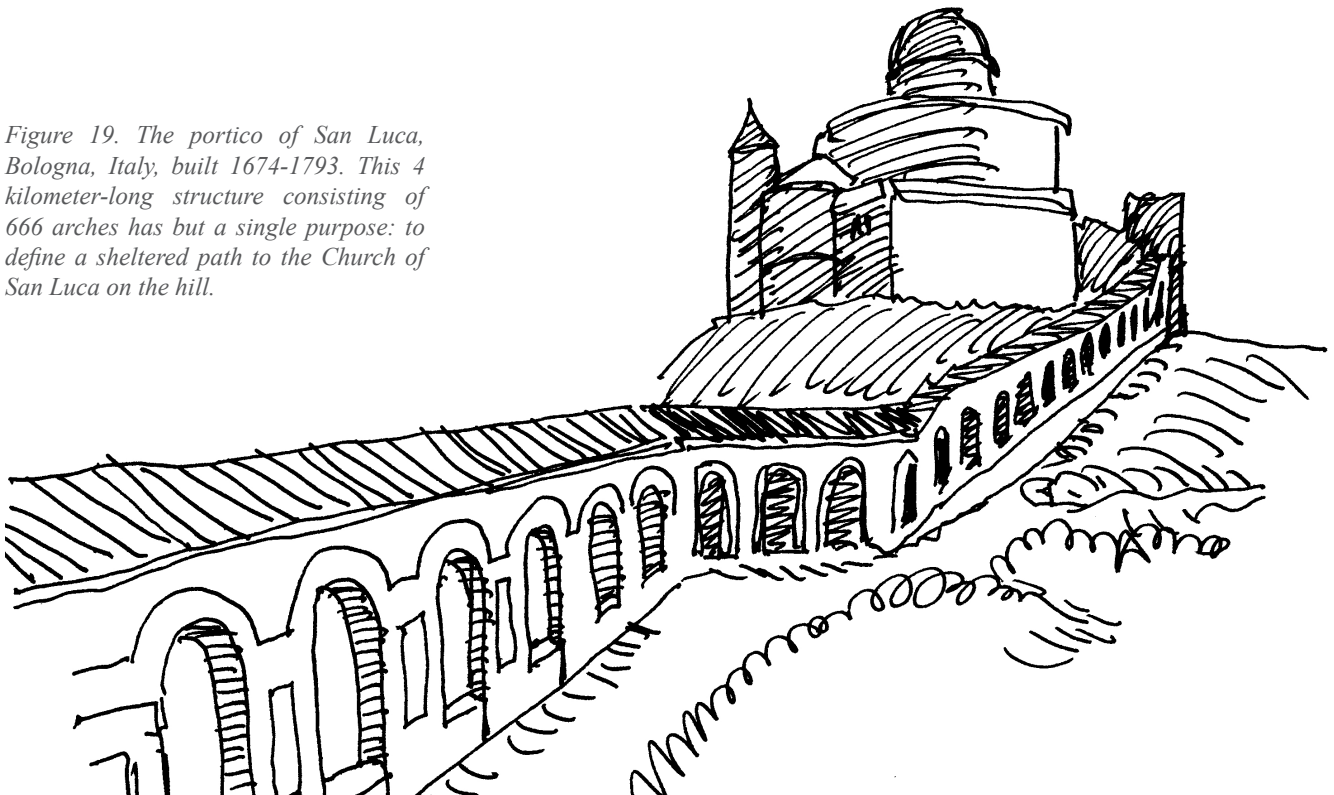


TABLE 3. ALEXANDRINE PATTERNS THAT DETERMINE PATHS (WITH MY OWN SUMMARIES)

Pattern 98.

Navigation must be intuitive and effortless. It helps to have an obvious sequence of flows, a correct positioning of paths, and appropriate supporting structures.

Pattern 114.

Satisfy the feeling of having one's back protected by a solid structure (refuge), while being able to see out to the world (prospect).

Pattern 120.

A path is composed of a sequence of intermediate destinations. Flow is governed by the body's instinctive movements and psychological reactions.

Pattern 121.

A successful path is also a welcoming space for people to linger in if they are not in a hurry.

Pattern 132.

Make indoor transition corridors short and visually interesting. Use natural light, and design corridors in the same way as the building's living space.

Almost all architects have been taught to think of space as fixed and static, whereas human movement and life always generate a dynamic interaction with our environment as we move through it. Life couples us to the structures we inhabit, our perception engaging an information field that shifts continuously as we move. Dynamic interaction determines the effect that the environment exerts on us as we move about, and these complex signals are static only when we are stationary. Adaptive design takes into account our visceral responses as a result of movement — the dynamic versus the static nature of information, which are entirely different.

The architectural experience of paths, for example, can be explained by understanding “dynamic biophilia”. Wayfinding, whether inside or outside, depends on our assessment of environmental information changing as we move about. Markers and signals help us navigate a space by continuously reinforcing our perception of how we are expected to flow through it, or, conversely, such signals, if poorly designed, hinder our movement with psychologically confusing cues (Lyons Stewart, 2015). Much directional and navigational information resides in visual patterns on the ground. These engage us and draw us to move forward, and keep us on the path. Studies performed in hospitals of where people unconsciously walk demonstrate how floor color and pattern direct circulation. On the other hand, some current design practices ignore or contradict natural pedestrian flow.

We respond intuitively to the information patterns of floors (Salingaros, 2006: Chapter 7). Visual floor patterns strongly influence the direction in which we move and the ease with which we move. Unfortunately, many floor surfaces are too plain visually to help guide circulation and movement. Even worse, we encounter patterned flooring that gives cues contradictory to the intended movement through a passage, and those subconscious signals confuse us and cause psychological stress. Debilitating consequences to patients can attend cognitively jarring floor patterns in hospitals, daycare centers, schools, and housing for the elderly (Lyons Stewart, 2015). Poorly designed floors burden walkers everywhere, but confusing hospital floors surely are to blame for the most painful and unnecessary awkwardness.

In conventional architectural practice, paths in buildings and other built spaces tend to be designed as abstractions. Artistic intent expressed on a plan too often trumps utility and human nature. That approach ignores both biophilia and the dynamics of human interaction with structures. People get lost because the architect or interior designer did not apply adaptive design to direct movement efficiently (Lyons Stewart, 2015). We frequently get ambiguous or even contradictory signals from the built environment as we move. The paths by which we navigate spaces can be disturbing — often generating the sensation that we would rather walk elsewhere but are thwarted by obstacles, either signs denying passage or structures blocking passage. We are biological creatures, after all, and respond subconsciously far more than we realize to the world around us.

A Pattern Language (Alexander *et al.*, 1977) presents design tools for indoor and outdoor paths that pay attention to human sensibilities. [For a background discussion on patterns, see Leitner (2015)]. The following

five living patterns provide the elements for a design template: Pattern 98, “Circulation Realms”; Pattern 114, “Hierarchy of Open Space”; Pattern 120, “Paths and Goals”; Pattern 121, “Path Shape”; Pattern 132, “Short Passages”. In particular, Pattern 114, “Hierarchy of Open Space”, anticipates and contains two notions later used by writers on biophilia: “refuge” is a psychologically safe space where we feel free from threat, whereas “prospect” means the ease of seeing locations some distance away that might attract us if we perceive obvious biophilic properties there (Browning *et al.*, 2014; Kellert *et al.*, 2008).

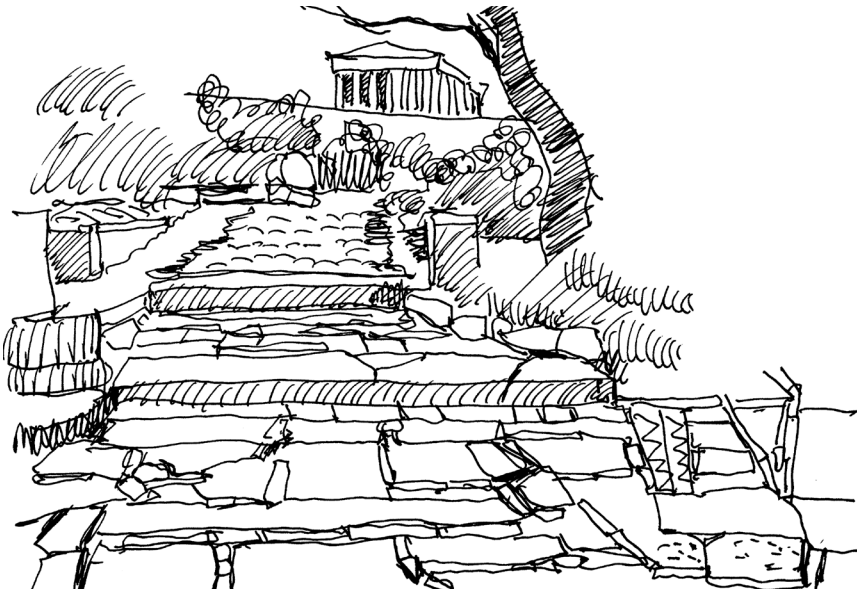


Figure 20. The paved path winding around the Acropolis Hill in Athens, Greece. Designed by Dimitris Pikionis, 1957.

Results from neurophysiology, living patterns, and biophilia reinforce and tie together concepts necessary for the design of paths. These fruits of our evolutionary development from human ancestral environments are arguably shared by primitive life forms that move about even to this day. Applying these design notions to paths, every portion of the spatial environment along a path must offer refuge so that a person feels safe and comfortable while negotiating that journey. At the same time, a prospect offers us a range of goals for our journey, if we choose to leave our refuge and move toward them. An intelligently designed path will, in theory, reduce our instinctive resistance to doing so.

If it is to contribute to a sustainable future for humanity, innovative architecture must foster the greatest possible number of psychologically nourishing interactions. Systemic harmony, organized complexity, and coherence in our surroundings are based on human neurophysiology, not abstract imagery (Alexander *et al.*, 1977; Browning *et al.*, 2014; Kellert *et al.*, 2008; Salingeros, 2005; 2006). Because adaptive design works *with* rather than *against* nature and climate, its energy expenditures are more sustainable. But healing environments are intrinsically sustainable more because they are loved viscerally—as our favorite historical rooms, buildings, and urban spaces are loved—by everyone who experiences them. They need not make “statements” to assert their “relevance”. People want to preserve healing environments because they are nourished by them. □

ENDNOTE

These ten essays first appeared online and are assembled here for the first time, with an introduction by Catherine Ryan. It should be very useful for students and practitioners wishing to apply Biophilic Design to their projects. The discipline of applying adaptive structure to architecture is under constant development, and while the ordered complexity of nature upon which it depends operates according to a rigid set of realities, applying them to design solutions need not limit designers to a rigid set of rules. Moreover, we are discovering more and more layers of mechanisms and processes that deeply influence the interaction of human beings with our environment. No simplistic explanation can be given for these complementary phenomena.

Biophilic Design is a new approach to design, based on eternal patterns of life, that is beginning to take off. Recent buildings and theoretical writings are stirring up interest, revealing remarkable opportunities for practitioners. Architects and researchers can each take a slightly different approach to this topic. Their explorations serve to expand and reinforce the subject's practical importance. For example, some contributions are coming from a natural/ecological perspective, whereas my research comes from the mathematical perspective. All of us agree on the basic principles of the method and on the necessity for living architecture to incorporate Biophilic Design.

Several authors are doing a great favor to the profession by giving Biophilic Design a broad and detailed coverage. These overlapping ideas will hopefully spark reflection in readers' minds. Architects will be faced with a take on design unfamiliar to most people, and will gain fresh insights into what makes architecture work. We hope to get people to think seriously about our claims so as to create new, healthier buildings and a more robust and sustainable built environment. A safer, lovelier, happier world can be the result.

APPENDIX

TWO MEANINGS OF BIOPHOBIA AS OBSTACLES TO BIOPHILIA

The term “biophobia” has two distinct meanings. The original meaning refers to an inherited, instinctive fear of specific animals such as snakes and spiders (Ulrich, 1993). It is believed that those fears are hard-wired, and represent an evolutionary advantage for human survival. Fear embodies an essential part of adaptive neurological response, enabling our ancestors to save themselves from particular natural threats. It became much more efficient when specific fears were eventually incorporated into inherited memory so as to provide us with an automatic response.

A very different and much broader definition of biophobia is used, for example, by David Orr to denote a fear of and aversion to *all* living things (Orr, 1993). This response against nature is learned, not inherited. Biophobia in this sense is a culturally-acquired trait. But that does not make it any less significant in determining our lives. Many people today have picked up biophobia because their world since birth is almost entirely an artificial one, with characteristic unnatural properties (e.g. industrial artifacts, surfaces, materials, and geometries). Such persons identify with sterile environmental qualities, and are consequently averse to the opposite biophilic qualities common to biological entities.

John Michael Greer (2015) joins those who posit that industrial society imposes biophobia on the population. There is intention in creating an artificial environment through which people pick up biophobia. This institutionalization of biophobia strongly influences conventional architectural education and practice. Positive reinforcement for biophobic projects, and punishment leading to negative reinforcement for biophilic ones, shape an architecture student’s worldview. In the profession itself, juries selecting winning projects and architecture prizes award biophobic designs while rejecting biophilic ones.

These considerations are important because they explain why it may be very difficult for persons indoctrinated into pervasive biophobia to read the present publication. The drawings used for the illustrations will trigger a biophobic response analogous to the original biophobic alarm from snakes and spiders, before even getting to the text to discover what it says. That is because the artifacts and buildings shown, as well as *the quality of the drawings themselves*, are biophilic. Even those negative examples of minimalist or deconstructivist buildings are drawn by hand in a biophilic manner, not in the usual lifeless computer rendering. Readers can draw their own conclusions from this.

FURTHER READING

An interest in understanding Biophilic Design leads into other related topics. From ancient subjects such as the Golden Ratio, to more current ones such as Complexity and Organization, Alexandrine Patterns, and Evolving Morphogenesis, today's practitioners increasingly feel the need for solid background knowledge. Like Biophilia, those topics are poorly explained in the conventional literature on architecture and design. Some of my articles listed here cover parts of this information, separately from the references to the above essays. Most of them are freely available online.

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**“Somehow, a person’s own self is mobilized, liberated,
made more strong by that person’s success in making life in the world.
It is as if the life in the world which is created, directly nourishes the person.”**

Christopher Alexander
(Alexander, 2001–2005: Book 4, page 269)



TERRAPIN
BRIGHT GREEN

METROPOLIS