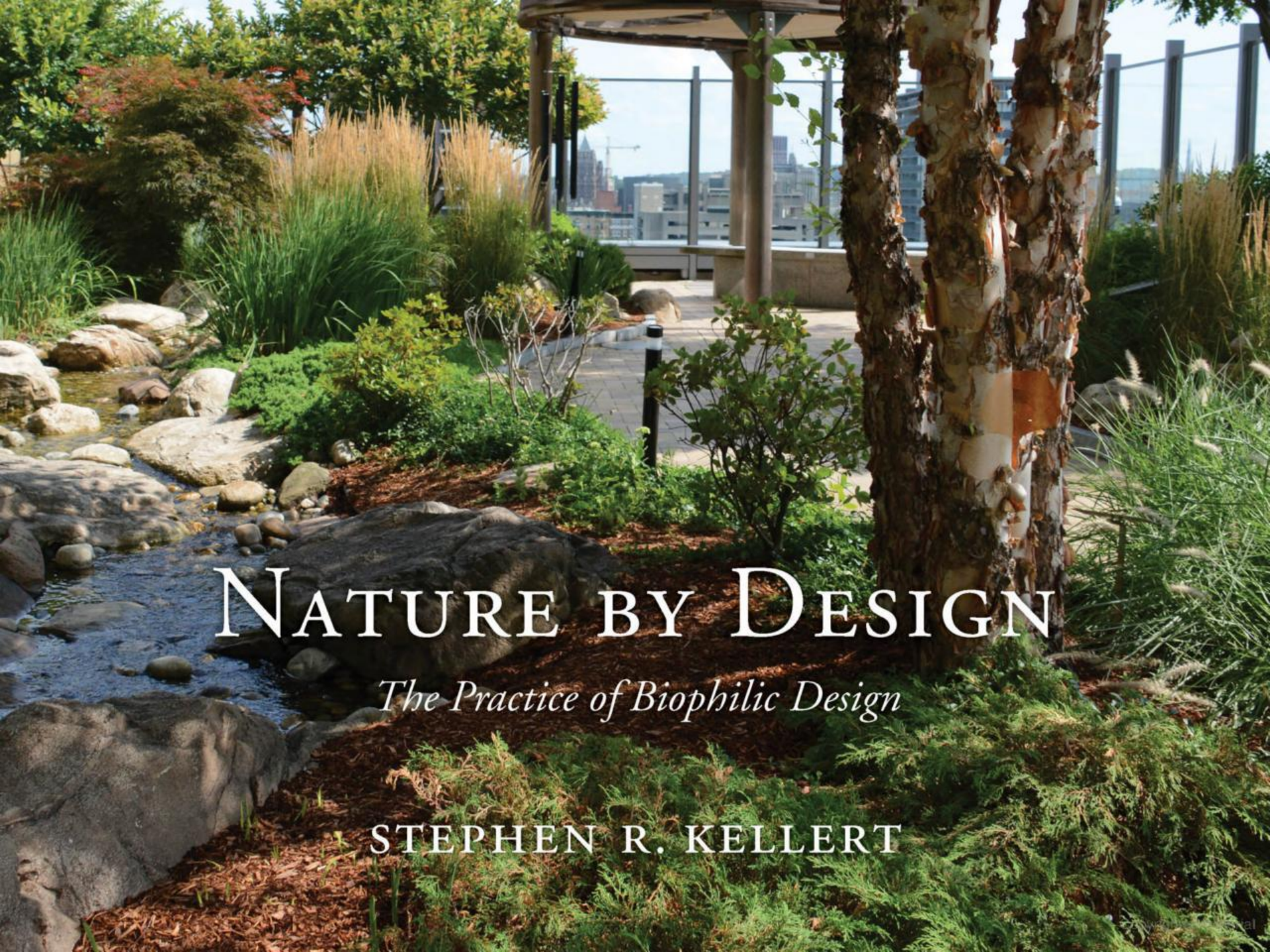

# Nature by Design

*The Practice of Biophilic Design*

Stephen R. Kellert

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## THE PRACTICE OF BIOPHILIC DESIGN

STEPHEN R. KELLERT

Yale UNIVERSITY PRESS/NEW HAVEN & LONDON

We gratefully acknowledge funding from Interface, Inc.,
which supported the research and illustrations program.

Frontispiece: The Portcullis House courtyard, designed by Hopkins Architects Partnership LLP, connects parliamentary offices in London. It is a compelling and enthralling combination of both direct and indirect biophilic design features. The natural world is brought inside by the column of trees and the water pools. And the spiderweb-like framing of the roof and its skylights makes the connection to nature even more dramatic.



Designed by Mary Valencia.
Set in Adobe Garamond type by Tseng Information Systems, Inc.
Printed in China.

Library of Congress Control Number: 2017943458
ISBN 978-0-300-21453-6 (hardcover : alk. paper)

A catalogue record for this book is available from the British Library.

This paper meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

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# PREFACE

*Biophilia* refers to the inherent affinity people have for the natural world. This inborn tendency developed during the long course of human evolution when people largely adapted to natural, not artificial or human-made, forces. Assuming this biological inclination continues to be vital to human health and wellbeing, one of the great challenges of our time is to foster beneficial contact with nature in our built environments, where we now on average spend 90 percent of our time. The challenge of biophilic design—biophilia in the human-built environment—is the focus of this book.

People have, in fact, practiced forms of biophilic design over the ages, although largely in an intuitive and iterative manner, influenced by factors related to history, geography, ecology, and culture. Today we are compelled to take a more systematic and deliberate approach to the application of biophilic design, for two reasons. First, our society has largely assumed an adversarial relationship to nature, mainly seeing it as an obstacle to dominate and overcome—a mere natural resource to be transformed through technology to some higher use, or a nice, but not necessary, recreational and aesthetic amenity. Stressing the importance of nature in our largely constructed and created world is often viewed as a low priority and romantic perspective. To advance the objectives of biophilic design, we must demonstrate that nature substantially enhances human physical and mental health, performance, and wellbeing. Second, the rapid pace and large-scale approach of

much modern development has magnified the adverse effects of ignoring the need for biophilic design and made these effects difficult to correct. We can no longer rely on good intentions and architectural insight to effectively incorporate nature into the built environment. Biophilic design provides instead a more deliberate, systematic, and informed approach to bringing beneficial contact with nature into the modern built environment.

This book offers a rationale, framework, and methodology for accomplishing this objective. Yet it is far from the final word on the subject. The understanding of biophilic design has been rapidly evolving in recent years and is still a relatively new approach. Additional improvements will undoubtedly occur as a result of new knowledge and refinements in the years ahead.

A number of important biophilic design publications and online manuscripts have appeared in recent years that have greatly assisted the author in writing this book. Of special importance have been initiatives of the design studio Terrapin Bright Green, particularly the work of Bill Browning and Catie Ryan on "14 Patterns of Biophilic Design and the Economics of Biophilia." In addition, the insightful and prolific biophilic design work of Judith Heerwagen, an environmental psychologist at the University of Washington, has been exceptionally helpful. The work of the architect Nikos Salingaros and the Living Building Challenge have further provided important understandings, insights, and methodologies.

This book will inevitably reflect my biases and limitations. Moreover, my aim is not to specify how biophilic design should be applied in every circumstance. Variations in setting, cost, and culture will inevitably result in a wide diversity of applications of biophilic design. To paraphrase Judith Heerwagen, biophilic design does not tell a designer or developer what he or she should do, but rather what is important. Once the significance of biophilic design has been established and ways suggested for how it may occur, a wide choice of possibilities emerge for effectively incorporating nature into the built

environment. What this book does do is present basic principles, practices, and strategies for achieving biophilic design. The goal is to identify a menu of options, which the designer can then employ depending on a project's particular conditions and circumstances.

A basic consideration is how biophilic design relates to what has been called sustainability or low-environmental-impact design. As the term implies, low-environmental-impact design is intended to minimize and avoid the adverse effects of the built environment on natural systems and human health that result from such practices as excess resource and energy use, pollution, climate emissions, loss of biodiversity, and more. Biophilic design embodies the opposite side of the same coin—how human health and wellbeing can be enriched through beneficial contact with natural systems and processes. True and lasting sustainability depends on combining low-environmental-impact and biophilic design. Low-environmental-impact design aims to minimize the damaging effects of the built environment, whereas biophilic design provides the rationale and motivation to maintain and be good stewards of our buildings, landscapes, and communities. If only one approach to sustainability is used, the resulting creation tends to fail both people and nature over time.

Because I am a scientifically trained scholar, my other books have mostly relied on the written word and statistics to convey knowledge and advocate certain policy positions. Having worked with designers and developers over the past several years, however, I have come to appreciate the important roles of graphic designers and illustrators. For example, I recall when an architect friend who read an earlier book of mine on biophilic design, and then saw a film we made of the subject, turned to me following the video and said: "Steve, now I get it. I'm an architect. I need to see pictures before I understand anything." To those professionals for whom an illustration may be worth a thousand words, this book provides some relief in employing more than one hundred figures, though even this large number hardly measures up to the complexity and importance of its message.

Selecting these illustrations was a time-consuming and often difficult challenge, and securing permission for their use sometimes even more so. For making this process immeasurably more feasible, I want to thank Melissa Flamson and her colleagues at the company With Permission. In addition, the graphic artists Stephen Harrington and Bill Nelson provided a number of highly effective and evocative line illustrations.

Including so many color illustrations in a larger format book could not have occurred without the invaluable support of the Interface, Inc. I especially appreciate the assistance and support of David Gerson in this regard. Interface, founded by the visionary Ray Anderson, has long championed and pioneered the practice of sustainability and biophilic design.

Once again, I deeply appreciate the support, advice, and encouragement of my extraordinary senior executive editor at Yale University Press, Jean Thomson Black, and her assistant, Michael Deneen. I also greatly appreciate all the support provided by my wife, Cilla.

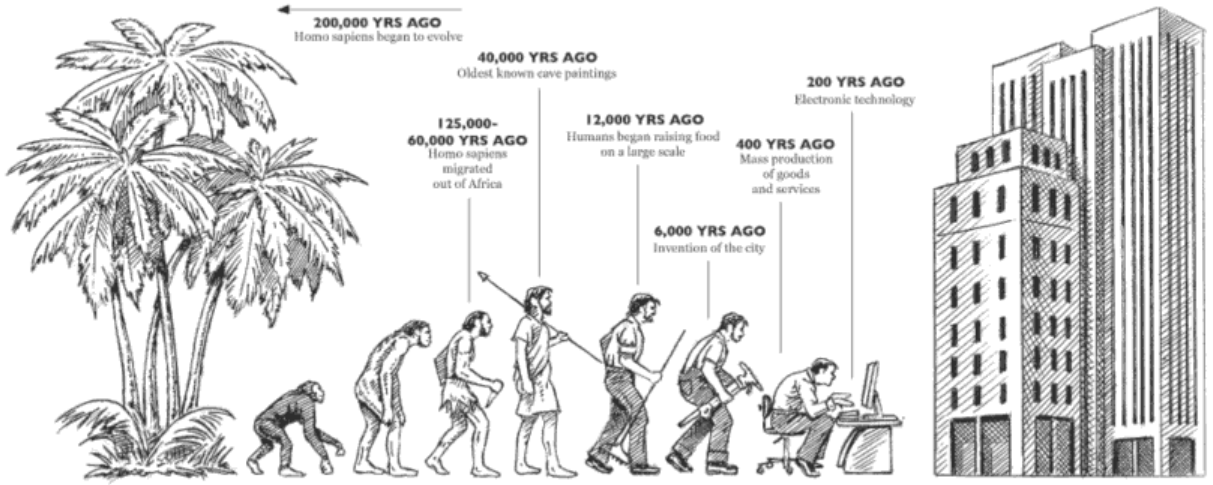


Figure 1.1. For much of human history, people evolved in adaptive response to natural, not human-made, forces and stimuli. This figure provides a somewhat facetious perspective of the human shift from living mainly in nature to surviving in today's designed and built world. Ancient cave and modern electronic humans amusingly resemble one another in their inclination to bend rather than stand erect.

tunately, modern society has increasingly viewed the experience of nature as a mere vestige of the past, a remnant now largely reflected in a dispensable recreational and aesthetic amenity. People are ever more separated from nature in today's world, especially in the modern city and built environment.

This growing disconnect from nature is due to many factors. Fundamentally, it reflects the underlying assumptions of a technologically oriented, sedentary society that spends most of its time indoors and regards exposure to nature as mainly primitive and backward. Figure 1.1 depicts one facetious view of the continuing evolutionary significance of humans in the modern world.

Despite our temptation to dismiss the importance of nature, mounting evidence suggests that our inborn tendency to connect with the natural world continues to be highly important for human health, productivity, and wellbeing. From this perspective, a major challenge of our time is determining how to incorporate the beneficial experience of nature into the built environment. The objective of those who care about biophilic design is to create good habitat for people as biological animals in the places we live, work, and reside.

Because this book focuses on satisfying the conditions of biophilia in the built environment, the temptation is to move quickly to this focus on biophilic design. This would be a mistake, however, given that many observed failures and shortcomings of biophilic design have reflected an insufficient understanding of biophilia. Biophilic design does not involve simply applying any form of nature to the built environment, but rather doing so in ways that effectively satisfy the inherent human inclination to affiliate with the natural world. As E. O. Wilson (1984) so poetically explains, biophilia is "the innate tendency to focus on life and lifelike processes … To affiliate with life is a deep and complicated process in mental development. To an extent still undervalued in philosophy and religion, our existence depends on this propensity, our spirit is woven from it, hope rises on its currents" (p. 1).

The concept of biophilia refers to aspects of nature that have figured most prominently in human evolution and development. This may appear to be a straightforward notion, but on closer examination it is a complex consideration. It leaves unanswered the question of which aspects of nature have been especially critical in advancing human health and wellbeing. It also fails to cite the ways in which people are inherently inclined to attach meaning to, derive benefit from, and, in effect, value the natural world. Finally, it

avoids the question of how people can internalize or learn from their experience of nature to the extent that it actually enhances their health, productivity, and wellbeing. I provide a detailed examination of these issues in my 2012 book *Birthright: People and Nature in the Modern World*. Still, these issues should be briefly addressed here, and serve as the basis for the basic principles and practices of biophilic design described in subsequent chapters.

The human biological response to nature has tended to focus on certain species and natural processes that have figured most prominently in human evolution and development. For example, people are especially prone to react to other forms of life that have been particularly connected with our survival: consider those creatures that facilitated our sustenance and safety, such as horses, dogs, and cattle; large and fearsome predators like wolves, great cats, and bears; and a wide variety of other species (estimated at nearly a hundred thousand) that have significantly affected human success. We are also predisposed to like certain edible, flowering, and fruiting plants, as well as to avoid those that are typically regarded as potentially toxic or dangerous. Other natural conditions of special significance to people have included qualities of light and air, the availability and drinkability of water, the vagaries of weather, and a host of ecological characteristics, knowledge of which advanced human security and wellbeing. For example, certain landscapes and geological forms have been found to be especially important in human evolution, such as savannah-type settings, forested edges, watercourses, mountains, and valleys.

Without question, certain senses have been especially critical for human evolution and survival. Humans are primarily and historically diurnal or daytime creatures, and as a result, vision is especially important and dominant. Those who could see long distances, use color to spot resources and opportunities, and visually organize and order complex settings fared better and so had an evolutionary advantage. Humans further developed the ability to respond quickly to natural settings by using a variety of strategies such as utilizing prospect and refuge (gaining a clear view of the landscape from a safe and secure

spot), employing certain natural geometries, processing the information richness of nature, and developing ecological and human social connections to place.

All these and more have all emerged as relevant to the practice of biophilic design, because these various preferential responses to nature determine how people can feel more comfortable, satisfied, secure, healthy, and productive in their built environments. Consequently, it is not enough to include just one natural feature or attribute in such spaces. Instead the effective practice of biophilic design depends on knowing and appreciating which features and processes of the natural world have been especially relevant to human functioning and so will offer the greatest benefit to people in today's modern setting.

Toward this end, eight values of biophilia have been identified, each potentially relevant to the advancement of human health and fitness, and each a legitimate focus and outcome of biophilic design (Kellert 2012). The content and priority of these values vary greatly depending on people's distinctive backgrounds, experience, learning, and cultures. Yet each value is universally present in all humans, contributing in different ways to human welfare and wellbeing.

The eight biophilic values and their frequently associated benefits are

· *Affection:* The human tendency to express strong emotional attachment and at times love for features of the natural world. Commonly associated benefits include the ability to bond, care, and connect emotionally with others.

· *Attraction:* People's inherent aesthetic attraction and ability to perceive beauty in nature. Associated benefits include feelings of harmony and symmetry, emotional and intellectual development, and enhanced capacities for imagination and creativity.

· *Aversion:* The inclination to avoid aspects of nature that generate feelings of anxiety, threat, and sometimes fear. Benefits include enhanced safety and security, coping and competitive skills, and sometimes a sense of awe and respect for powers greater than one's own.

• *Control:* The tendency to master, dominate, and, at times, subjugate nature. Benefits include enhanced mastery and problem-solving skills, critical thinking, and cognitive development.

• *Exploitation:* The tendency to utilize the natural world as a source of materials and resources. Commonly associated benefits include enhanced security, extractive abilities, and practical skills.

• *Intellect:* The inclination to use nature as a means for advancing rational thought and intellectual development. Benefits include cognitive skills, empirical and observational abilities, critical thinking, and learning.

• *Symbolism:* The tendency to employ the image of nature to advance communication and abstract thought. Important benefits include the capacities for language and culture, intellectual development, and enhanced imagination and creativity.

• *Spirituality:* The inclination to experience nature as a means for achieving a sense of meaning, purpose, and connection to creation. Associated benefits include feelings of meaningful and purposeful existence, enhanced self-confidence, and bonding with others.

The adaptive occurrence of any biophilic value depends on experience, learning, and social support. People do not benefit from contact with nature unless this involves engaging and recurring, rather than isolated, experiences. Effectively incorporating nature into people's lives in a lasting, meaningful way requires building a supportive learning environment that relates to people's everyday world, and encouraging the involvement of significant others such as family, friends, peers, and community members. Single or sporadic exposures to nature that have only limited relevance to others typically exert little lasting benefit over time.

The importance of these values of biophilia and their dependence on learning and experience raises the question: what does biophilia have to do with the design of the mod-

For example, various healthcare studies have reported that exposure to nature can reduce stress, lower blood pressure, provide pain relief, and contribute to healing and recovery from illness. Among hospital staff, contact with nature has been linked to employee satisfaction and morale, improved performance, and enhanced recruitment and retention. A 2011 review of more than one hundred healthcare studies (Annerstedt and Währborg 2011) reported a wide spectrum of physical, mental, and behavioral benefits associated with exposure to nature.

In another example, Roger Ulrich (1984) undertook a study of patients recovering from gallbladder surgery who were demographically similar and randomly assigned to hospital rooms. All rooms had windows, although some offered a view of a brick wall, whereas others overlooked an ordinary tree grove. The patients assigned to the rooms with the brick wall view had slower recovery times, required more potent painkillers, expressed greater dissatisfaction with their care, and generated more frequent complaints according to nursing notes. By contrast, Ulrich reported, "Patients with the nature window view had shorter post-surgical hospital stays . . . fewer minor post-surgical complications, far fewer negative comments in nurses' notes. The wall view patients required far more potent pain killers" (107).

Positive health benefits have also been reported among disabled and sick children exposed to nature. These studies indicate higher rates of adult diabetes, myopia, and obesity among children lacking contact with nature, while exposure to nature is correlated with reductions in allergies, asthma, and, at times, symptoms of autism and attention deficit disorder.

Various work-related studies have reported physical and mental improvements associated with increased exposure to nature. These benefits include enhanced health, improved morale and motivation, better worker performance, and superior employee recruitment and retention. Research focusing on office workers found that improvements

in natural lighting, exposure to plants, outside views, and pictures of nature often contributed to employee performance and wellbeing. A largely anecdotal study reported that better natural lighting, the design of interior park-like spaces, and water features led to highly paid professionals volunteering to work longer hours and collaborating more. Yet the average office worker in the United States toils in a windowless and largely sensory-deprived environment. These often-featureless settings have been compared to the barren cages of an old-style zoo, the kinds of enclosures that are now, ironically, banned as inhumane for nonhuman animals.

Judith Heerwagen (2000) has conducted perhaps the most significant work-related research in biophilic design to date. The office and manufacturing complex she studied, designed for an office-furniture manufacturer by the architect William McDonough, includes such biophilic features as extensive interior vegetation, widespread natural lighting, a restored prairie landscape, trails, and sitting places. Surveys administered to workers before, immediately after, and nine months following the project's completion found, even after nine months, a 22 percent increase in worker productivity, significant gains in worker motivation and emotional satisfaction, reductions in absenteeism and stress, and a 20 percent increase in a "sense of well-being."

Conventionally designed schools typically emphasize indoor, nonexperiential, abstract learning that removes students from contact with nature. Some schools, however, have incorporated natural lighting, natural materials, interior plants, and exposure to the outside environment. Studies have generally found that students in these schools have higher test scores, as well as improved attendance and motivation; teachers and other staff, too, have better performance, morale, recruitment, and retention. A recent national study (Kellert and David J. Case & Associates 2016) of some 1,500 eight- to twelve-year-old children and their parents found that increasing the children's contact with nature correlated with superior learning and development. Children with greater exposure to

nature reported greater physical strength and coordination, better self-esteem and self-confidence, an enhanced ability to cope with challenge and adversity, and higher critical-thinking, problem-solving, and creative abilities.

At the community and urban scales, research findings have indicated that the presence of trees, open space, and other appealing natural features often can contribute to resident health and wellbeing. One study of a 250-square-mile watershed in south-central Connecticut examined the relationship among environmental quality, human quality of life, and environmental values among eighteen rural, suburban, and urban neighborhoods. Such environmental quality indicators as pollution levels, amount of nonindigenous plants, hydrological flow, and nutrient flux were significantly correlated to the residents' quality of life. This relationship applied to all socioeconomic groups and occurred in urban as well as nonurban communities.

The universality of this finding is important because many dismiss contact with nature as a luxury for those with the time and resources to enjoy it, and so as an experience largely irrelevant to impoverished people who have more immediate practical priorities. Yet research at a Chicago public housing project among very poor residents revealed a strong correlation between exposure to nature and various physical and mental health benefits. The public housing project consisted of architecturally unattractive high-rise buildings, some surrounded by poorly maintained grass and trees, and others, by concrete and asphalt. After controlling for many potentially confounding factors, the researchers reported that those living in housing units surrounded by vegetation had superior coping abilities, greater optimism, lower drug and crime rates, a greater knowledge of their neighbors, and better cognitive functioning than those living in buildings surrounded by only a hard, unnatural surface.

Kathleen Wolf and colleagues (2015) at the University of Washington, in collaboration with the U.S. Forest Service, have summarized the health and social benefits of

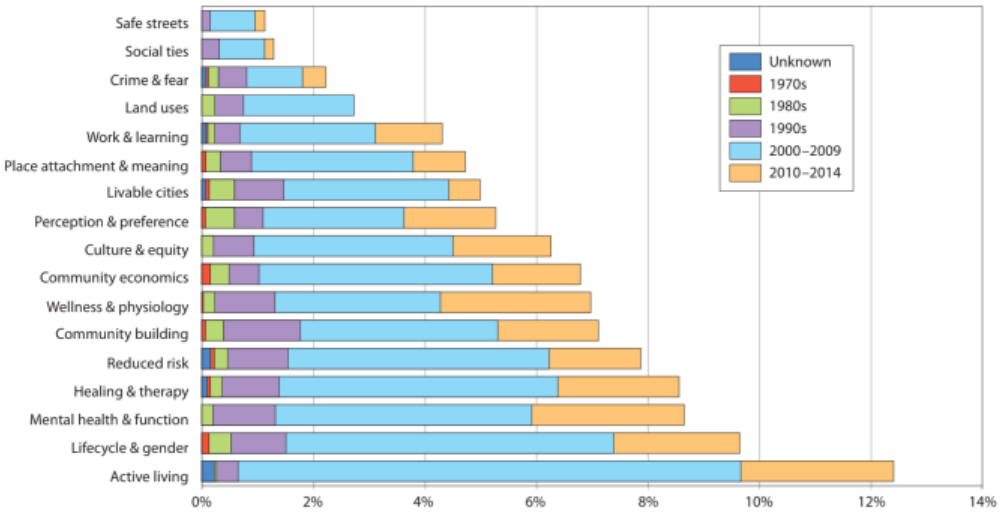


Figure 1.2. Frequency of various characteristics of urban life, from the article database for Green Cities: Good Health, a web portal to scientific evidence concerning the relationships of metro nature to human health and wellness. The article database contains about 3,100 peer-reviewed journal articles and reports, as well as technical reports from agencies, universities, and non-governmental organizations. The website, www.greenhealth.washington.edu, is sponsored by the University of Washington, and the project director is Kathleen L. Wolf, Ph.D. Funding for assembling the database and preparing the literature summaries is provided by the USDA Forest Service.

people living in urban environments with greater contact with nature. They drew on a database of more than three thousand peer-reviewed studies, sourced from nations all around the world. Although these research projects are often substantially different from one another, they consistently indicate that exposure to nature in urban areas contributes important physical and mental health gains and community-level improvements (Figure 1.2).

This limited review of studies in health, work, education, childhood development,

and urban planning supports the conclusion that biophilia, instead of being irrelevant and vestigial, continues to play a critical role in the relation of nature to human health and wellbeing. Even in our increasingly urban society, exposure to natural features and processes remains an anvil on which human fitness and wellbeing are forged. Denying or diminishing this need for contact with nature will likely impoverish the human body, mind, and spirit.

## THE MODERN DISCONNECT FROM NATURE

Contemporary society's growing separation from nature, particularly in the design and development of the modern built environment, is partly a function of our increasingly indoor, urban, and technological-oriented existence. It reflects a deeply held belief that progress and civilization depend on the ever-expanding capacity to control, convert, and transcend nature. This conviction is widely encountered in our practices of agriculture, medicine, manufacturing, education, work, urban planning, and design practices related to architecture and other built environments. Modern society typically views nature as mainly an obstacle to overcome through science and technology, or only marginally relevant and so a dispensable aesthetic and recreational amenity.

The prevailing paradigm of modern building and landscape design reflects these assumptions of the limited importance and relevance of contact with nature. The great majority of our structures used for purposes related to healthcare; education; manufacturing; hospitality; commercial, retail, and office tasks; and even religion and spirituality reveal this attitude. These modern constructions are often dominated by the use of human-made materials, artificial lighting, processed air, and sensory-deprived environments with little connection to the culture or ecology of the places where they occur. These structures generally endorse a standard of global "international architecture," where building design

TWO

# Principles of Biophilic Design

One of the great challenges of our time is to bring the beneficial experience of nature into the design of contemporary buildings, landscapes, communities, and cities. Devising strategies for including the natural experience in these built structures requires engaging all of the broad tenets and principles of biophilic design.

Biophilic design can be defined as biophilia applied to the design and development of the human built environment. Biophilic design thus derives from a basic understanding of human evolutionary biology and how our inherent inclination to affiliate with nature has historically contributed and even today continues to contribute to human health, fitness, and wellbeing. The fundamental goal of biophilic design is to create good habitats for people as biological animals. Like all species, human functioning depends on being part of an ecological system of interrelated, mutually reinforcing, and integrated parts that constitute a whole greater than its constituent elements. This means designing the built environment to meet our inherent tendencies to affiliate with nature in ecologically connected and complementary ways.

A number of basic principles of biophilic design emerge from this understanding, each of which constitutes a basic condition for its successful application. Rather than simply inserting nature into the built environment, these principles of biophilic design reflect the understanding that humans evolved in adaptive response to nature, and this

knowledge can be used to design buildings and landscapes that advance people's health and productivity. Ineffective applications of nature in the built environment occur when these basic tenets of biophilia are ignored.

These nine universal principles sometimes overlap, and their order of presentation does not suggest any priority of importance. Still, each principle provides a foundation for the effective practice and application of biophilic design.

### 1. BIOPHILIC DESIGN FOCUSES ON HUMAN ADAPTATIONS TO NATURE THAT ADVANCE PHYSICAL AND MENTAL HEALTH, PERFORMANCE, AND WELLBEING.

Exposure to nature in the built environment should advance human health and productivity. Biophilic design is not effective if it results in little or no sustained impact on people's physical or mental wellbeing. Isolated contact with nature in a building or landscape—a single plant, a sequestered image of nature, an inaccessible green roof—typically yields little beneficial effect over time; instead these elements often become ignored or relegated to a mere decorative object.

### 2. BIOPHILIC DESIGN CREATES INTERRELATED AND INTEGRATED SETTINGS WHERE THE ECOLOGICAL WHOLE IS EXPERIENCED MORE THAN ITS INDIVIDUAL PARTS.

Biophilic design should create complementary and integrated connections among the constituent parts of an overall setting that together constitute a functioning ecological whole. When contact with nature in the built environment lacks relationships to other experiences of the natural world and the overall design of a space, these occurrences of na-

ture have a limited impact, becoming simply superficial or decorative curiosities. For example, few sustained or substantial benefits arise from a largely inaccessible outdoors area, a skillful but isolated landscape painting, or a vertical green wall at variance with other features of an overall space. These isolated experiences of nature can even at times yield perverse effects, such as reinforcing the human tendency to exploit and subjugate nature for mainly superficial entertainment and aesthetic purposes. Biophilic design should create an overall ecological setting where various forms of relationship to the natural world complement one another and connect with other design features of a space.

### 3. BIOPHILIC DESIGN ENCOURAGES ENGAGEMENT AND IMMERSION IN NATURAL FEATURES AND PROCESSES.

A built environment that is responsive to human biophilic needs uses engaging and repeated experiences, learning, and social support to become an integral and beneficial part of people's lives. Infrequent and intermittent contact with nature, or nature-based experiences that are largely unsupported by the values and culture of a group, generally result in few long-term benefits. The beneficial experience of natural features and processes necessitates engaging, immersive, and repeated contact that becomes integral to a person's ongoing reality.

### 4. BIOPHILIC DESIGN IS STRENGTHENED BY SATISFYING A WIDE RANGE OF VALUES THAT PEOPLE INHERENTLY HOLD ABOUT THE NATURAL WORLD.

Chapter 1 described eight inherent ways that people attach meaning to, derive benefit from, and value the natural world. These biophilic values range from the tendency to

exploit, control, avoid, and symbolize nature, to expressions of affection, attraction, intellectual interest, and reverence for natural environments. Successful biophilic design satisfies a diversity of these inherent values of nature. Buildings and landscapes that focus on a single value—such as an organically shaped structure that is designed mainly to make an aesthetic statement, a building that is solely intended to exploit nature, or a learning institution that only focuses on cognitive development—generally elicit little long-term attachment, interest, or benefit.

### 5. SUCCESSFUL BIOPHILIC DESIGN RESULTS IN EMOTIONAL ATTACHMENTS TO STRUCTURES, LANDSCAPES, AND PLACES.

People develop emotional attachments to the spaces they occupy when these places consistently contribute to their comfort, satisfaction, health, productivity, and wellbeing. These spaces become part of their identity, motivating them to become good stewards and sustain these structures. By contrast, when people lack an emotional attachment to particular buildings and places, they typically neglect or even abuse these spaces. Even settings with features that are environmentally friendly, such as energy or resource efficiency and nonpolluting emissions, are rarely well maintained and sustained over time if people's relationships to these structures lack sufficient levels of emotional affection and commitment.

### 6. BIOPHILIC DESIGN FOSTERS FEELINGS OF MEMBERSHIP IN A COMMUNITY THAT INCLUDES BOTH PEOPLE AND THE NONHUMAN ENVIRONMENT.

Effective biophilic design enhances our sense of connection to nature—a relationship fundamental to an idea of community that includes other people as well as the natural

environment. Windowless office cubicles, featureless meeting rooms, and isolated dining areas instead typically reinforce feelings of separation and aloneness. Effective biophilic design, in effect, encourages a depth of interaction and collaboration among people and the natural environment that yields a willingness to share knowledge, resources, and skills.

### 7. BIOPHILIC DESIGN OCCURS IN A MULTIPLICITY OF SETTINGS, INCLUDING INTERIOR, EXTERIOR, AND TRANSITIONAL SPACES AND LANDSCAPES.

Contact with nature in the built environment should occur in a variety of spatial contexts, including interior and exterior settings as well as transitional spaces that connect building interiors with the outside. The beneficial effects of contact with nature tend to increase when interior and exterior environments are connected and even thematically organized. Interior spaces that seem at variance with the outside environment usually breed confusion.

### 8. EFFECTIVE BIOPHILIC DESIGN INVOLVES AN "AUTHENTIC" EXPERIENCE OF NATURE, RATHER THAN ONE THAT IS ARTIFICIAL OR CONTRIVED.

A successful biophilic experience of nature in the built environment fosters feelings of authenticity and being connected with genuine, and ecologically self-sustaining, natural features and processes. Buildings and landscapes that strike people as artificial and contrived in their natural elements typically exert little lasting benefit over time, and even can provoke scorn and derision. An isolated planter, captive non-native organisms, or artificial furnishings are instead often perceived as inauthentic and artificial.

is important, and how one might effectively incorporate nature into the built environment. For these practices to work well, they must be appropriately tailored, interrelated, and integrated into a coherent whole that reflects the particular conditions of a distinctive setting.

With these cautions in mind, I identify and describe here a range of strategies for the practice of biophilic design—including three basic elements and twenty-five associated attributes. Each of the three elements represents fundamental ways that people experience nature: the direct experience of nature, the indirect experience of nature, and the experience of space and place. The twenty-five specific strategies associated with each element involve the actual practice of biophilic design. Illustrations provide context and a diverse set of real-world examples, but there were limits to how many could be selected; therefore they offer only a partial indication of a particular biophilic design practice.

The *direct experience of nature* involves actual contact with basic features and characteristics of the natural environment. These include such naturalistic features as light, air, water, plants, animals, landscapes, weather, views of nature and the outdoors, and fire. A tendency exists to regard biophilic design as involving only the direct experience of nature. Although these features are all important, the direct experience of nature represents only a starting point for effectively engaging with nature in the built environment.

The *indirect experience of nature* relies instead on images or other representations of nature, features of the natural world transformed from their original state, and particular natural patterns and processes that have been especially instrumental in human evolution. The indirect experience of nature often draws on the unique human capacity to convert empirical and objective reality into symbolic and metaphorical forms through projecting thoughts, images, and feelings. Indeed, the symbolic use of nature underlies much of human communication, inventiveness, and the practice of biophilic design.

Providing an indirect experience of nature entails the use of images, pictures, paint-

ings, and other representations of the natural world. The indirect experience of nature also involves the transformation of natural materials such as wood, wool, metal, and leather into an array of products such as coverings, furnishings, and building materials. More subtle patterns and processes occurring in the natural world with special evolutionary significance to people may also be a part of the indirect experience—for example, certain textures, colors, natural geometries, the passage of time, aging, the simulation of light and air, information richness, and the human attempt to mimic the biology and behavior of other organisms (often referred to as biomimicry).

The third basic element of biophilic design is *the experience of space and place.* The spatial setting is the focus here—in effect, the ecological context of the built environment and how people manage and organize their environmental circumstances. Attributes associated with the experience of space and place include prospect and refuge (discerning long distances from a protected and secure space), organized complexity (balancing detail and diversity with order), transitional spaces (linking inside and outside environments as well as interior spaces), mobility (effectively navigating a particular setting), ecological and cultural connections to place, and the integration of parts to wholes. These attributes of space and place reflect how successful human environments—those that promote both good health and greater productivity—depend on the creation of habitats of complementary and connected parts that comprise an overall ecological whole.

How do the human senses fit into this overall formulation? People experience their environment through a variety of senses including sight, sound, touch, smell, taste, time, and movement. Still, in humans the visual is by far the most dominant sense, and it is the primary way that people typically perceive and respond to plants, animals, water, landscapes, and other features of the natural environment. The dominance of the visual sense is due to people having evolved as mainly diurnal creatures highly reliant on sight to discern opportunities and dangers.

When people lack the actual sight of nature—for example, when confined to a windowless space, a barren landscape, or a featureless setting—they often experience confusion and anxiety. Yet despite our inclination to favor the visual sense, the other human senses of touch, smell, taste, sound, time, and movement also remain vital to human welfare and wellbeing. For example, people gravitate not only to the sight of water, but, not unusually, also to its sound, texture, movement, taste, and even smell.

The following description of strategies for the practice of biophilic design does not include a separate category involving the human senses. Instead the senses are a basic characteristic of how all the attributes of nature are experienced—an underlying variable that cuts across strategies of biophilic design. Still, the more senses that are aroused by a particular attribute of the biophilic design, the more likely that it will have effectively incorporated nature into the built environment.

Some caveats: first, this list largely reflects my particular knowledge and experience, although I have certainly been influenced by others. Alternative frameworks have been developed, although the current formulation has benefited in many ways from these other approaches. Second, the rapid development of our knowledge and understanding of the human relation to nature will likely result in further refinements and other revisions in the future. Finally, the order in which these attributes appear does not indicate any priority of importance, and some attributes inevitably overlap and interact with one another.

## EXPERIENCES AND ATTRIBUTES OF BIOPHILIC DESIGN

I. Direct Experience of Nature

1. Light
2. Air
3. Water

4. Plants
5. Animals
6. Landscapes
7. Weather
8. Views
9. Fire

II. Indirect Experience of Nature

10. Images
11. Materials
12. Texture
13. Color
14. Shapes and forms
15. Information richness
16. Change, age, and the patina of time
17. Natural geometries
18. Simulated natural light and air
19. Biomimicry

III. Experience of Space and Place

20. Prospect and refuge
21. Organized complexity
22. Mobility
23. Transitional spaces
24. Place
25. Integrating parts to create wholes

## I. Direct Experience of Nature

### 1. *Light*

Light is among the most basic aspects of life and human existence. The experience of natural light affects how people respond spatially and temporally, orient themselves to their surroundings, and relate to daylight patterns and shifts in the season. Humans adapt to the shifting conditions of light by responding to changes in weather conditions, the day and evening sky, and what have been called circadian rhythms. These fluctuations in light and dark help people orient themselves within an environment, move across spaces with relative ease and familiarity, experience comfort and good health, and be productive. When the exposure to natural light is impeded by, for example, a windowless space, artificial lighting, or the condition of constant light, people often suffer problems related to health, performance, and wellbeing.

Despite the importance of natural light, a common characteristic of modern construction is the widespread prevalence of artificial lighting in otherwise dark interior spaces. This technological advance has been vital to modern building and construction but it ignores the importance of natural lighting as a basis for human health and performance.

Fortunately, innovative biophilic design can greatly extend the reach of natural lighting deep into building interiors. Design strategies capable of bringing natural lighting into interior spaces often involve glass walls, clerestories, skylights, atria, reflective colors and materials, and mirrors that track the path of sunlight and reflect it into interior areas. Innovative artificial lighting can also mimic the spectral and ambient qualities of natural light.

Beyond simply exposing people to more natural light, biophilic design strategies can enhance the experience by manipulating qualities of light and darkness through varying intensities, the diffusion of light, the presence of light wells, and shadows. In this way,

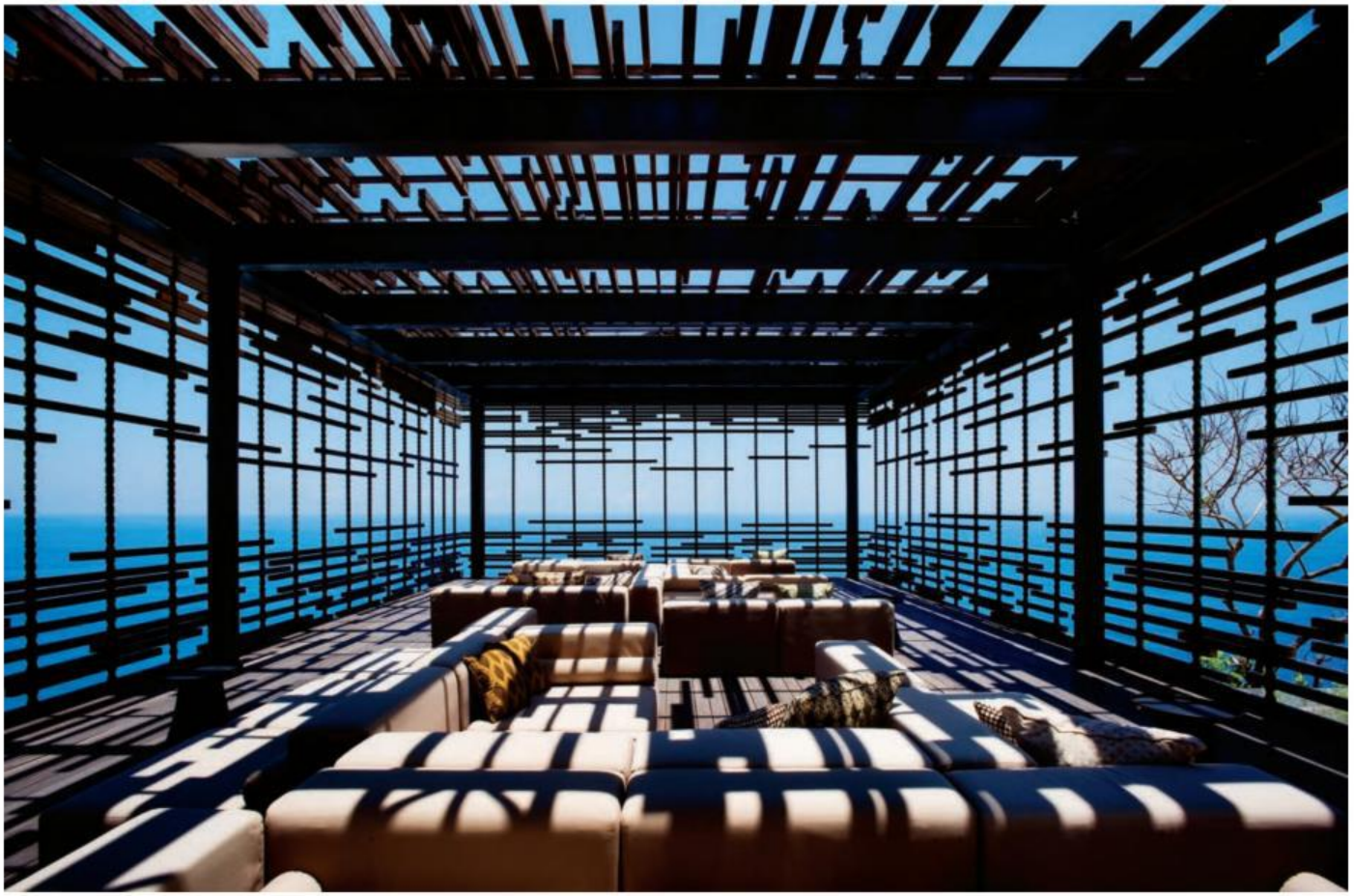

Figure 3.2. The Alila Hotel-Uluwatu in Bali, Indonesia, designed by WOHA Architects, provides strong connections between the interior and exterior environments. The structure's ocean views, wood material, reflecting pool, and extensive native plantings enhance the feeling of relationship to nature.

### 3. *Water*

Water is another basic condition of life and human existence, one that has made the Earth uniquely habitable. Despite its fundamental importance, however, it has become an increasingly hidden and a largely managed resource in the modern built environment. Unfortunately, many view water as a product of technology rather than an experience of nature. Its artificial control has facilitated the construction of enormous buildings with large and dense human aggregations. Yet the experience of water in the built environment has often become separated from the natural world, the result of engineering that encourages people to view this basic element of life as a resource to exploit rather than one to personally experience and celebrate.

Research has revealed that exposure to water can generate significant physical and mental benefits, including stress relief, enhanced performance, and improved problem solving and creativity. The sight of water is visually appealing and capable of engaging a wide variety of other senses including sound, movement, touch, taste, and smell. Water also frequently provides an experience that appeals to a diverse set of biophilic values. Beyond its obvious utility, water is also aesthetically appealing, intellectually stimulating, and emotionally arousing; it also can be a locus of control, a subject of fear, a basis for awe and reverence, and of great symbolic significance. For all of these reasons, the presence of water can transform an otherwise dull and uninspiring environment into one possessing extraordinary appeal and attraction, even if designing a direct water experience into the built environment can be difficult and problematic.

Strategies available for making water more evident include fountains, constructed wetlands, ponds, swales, waterfalls, rainwater spouts, and aquaria. Water is often especially appealing when it is in motion; when it is relatively clear, but contains sufficient nutrients to support life; and when it is capable of engaging a diverse array of senses. Indirect

strategies, such as pictures, video, audio technology, and certain patterns and designs can greatly assist the practice of biophilic design.

Two examples from very different parts of the world—the new campus of the University of Nottingham in England and a Buddhist temple complex in Japan—offer striking testimony to the appeal and profound value of water features in the human built environment (Figures 3.3, 3.4).

4. *Plants*

Plants are probably the most frequently employed strategy for creating direct contact between people and nature in the built environment. They are often designed to be a part of landscapes in close proximity to buildings, in building interiors, and in transitional spaces that mark the passage between indoor and outdoor settings. The beneficial effect of plants in the built environment has been highlighted in studies that indicate exposure to plants increases occupant comfort, health, and productivity. Even plants brought into windowless spaces have been found to relieve stress, enhance morale, and improve performance. The therapeutic benefit of plants has long been recognized; consider the tradition of bringing vegetation and flowers into hospitals, hotels, sacred spaces, and other settings.

The field of landscape architecture focuses on plant design in the outside environment near buildings. Few large-scale structures nowadays fail to include some degree of deliberate plant design. But unfortunately, many of these efforts involve highly artificial and contrived designs involving non-native vegetation and plantings and habitats that are formal and require continuous intensive management. A more biophilic and sustainable approach to landscape design would instead emphasize ecologically intact natural systems, native vegetation, and a more naturalistic design.

Plants are among the few living organisms that can be somewhat easily incorporated into building interiors. Effective biophilic design of interior plants should avoid creating

Figure 3.3. The new campus of the University of Nottingham, designed by Michael Hopkins Architects, incorporates a variety of biophilic features that distinguish the buildings and its surrounding space. These include the prominence of wood materials, natural lighting, and an overall sense of connection to the history and geography of the site. The prominence of water particularly provides a central focal point for integrating the space and gives vitality to this former industrial area.

Figure 3.4. Byōdō-in is a Buddhist temple complex located in Kyoto, Japan. Its most renowned building, Phoenix Hall, is a fine example of traditional Japanese architecture with its natural materials and organic shapes and forms. The surrounding pond accentuates the classic beauty of this wooden structure.

Figure 3.5. Optima Camelview Village, designed and developed by David Hovey, is a residential complex in Scottsdale, Arizona. The development includes extensive vegetation at multiple levels that reinforce the feeling of connection between the built and natural environments. The development's water features, natural materials, and textures further enhance these effects.

Figure 3.6. The vertically planted green wall on the facade of the Musée du quai Branly, designed by Patrick Blanc, inserts green plants into this highly urbanized setting. The adjacent building, although it lacks living organisms, subtly enhances this biophilic quality by virtue of its organic shapes and forms, natural materials, and natural geometries. The juxtaposition of all these elements elicits the human affinity for nature.

Figure 3.7. The fish, coral, and other aquatic organisms in this aquarium at the Smilow Cancer Center in New Haven, Connecticut, provide patients and staff with physical and mental relief in a highly stressful setting. Research has revealed that such tanks can provide substantial therapeutic benefits. Yet the healing effect is often minimized if the tank is isolated or at variance with other predominant features of a designed space.

Figure 3.8. The hand-forged bronze peacock doors at the Palmer House in Chicago, Illinois, designed by Louis Comfort Tiffany, are a lovely example of animal images used to enliven and enrich an essentially dark interior space.

## 6. *Landscapes*

Landscape design in close proximity to buildings and occasionally within building interiors is both a vital element of built environments as well as a common strategy for facilitating contact between people and nature in those environments. Careful planning and construction are required, however, to keep landscaping from becoming a largely superficial decoration rather than a meaningful experience of the natural world. We all have walked through and around uninspired landscape designs involving just a few high-maintenance non-native plant species. By contrast, an effective biophilic landscape can often exert more than a superficial effect on the people who experience it.

Certain landscape designs affect people because of their importance during the course of human evolution. These include spreading shrubs and trees, colorful foliage and flowers, the presence of water, long-prospect views, sheltered spaces, prominent trees, natural pathways, savannah-like settings, open understories, and forested edges. Studies indicate that even ordinary natural scenes depicting a coherent and ecologically connected landscape are generally more appealing to people than landscapes with artificial surfaces, few and exotic plants, an absence of geological features, and the dominance of human-made artifacts.

The most effective biophilic landscapes, then, are generally comprised of interconnected soils, waters, plants, animals, and geological forms revealed in a space that is ecologically coherent. These integrated and typically more resilient landscapes usually have high levels of biodiversity, tend to be self-sustaining, and satisfy a variety of ecosystem needs such as pollination, seed dispersal, decomposition, and pollution control.

Biophilic landscape designs can take many forms, including constructed wetlands, ponds, grasslands, prairies, forests, and other habitats. These landscapes are often enhanced by the presence of pathways, viewing areas, observational platforms, and other

expected events by creating consistent atmospheric conditions within these constructed environments. As in many other areas of modern life, our efforts may have been too successful. Highly insulated buildings can dull the senses and separate us from one of the most fundamental ways in which humans experience nature.

Two examples, the Ponta dos Ganchos resort in Brazil and the glass house near Tokyo, illustrate how an interior space can have a powerful connection to outside weather conditions (Figures 3.10, 3.11).

People benefit from knowing the meteorological conditions of their external environment, including the quality of sunlight, the likelihood of fair or foul conditions, and other aspects of weather. When denied access and awareness of weather, many people become anxious and disoriented. By contrast, the architect Kevin Nute (2004) points out the advantages of remaining aware of the weather: "Rethinking the way buildings interact with weather could not only help us to remain more alert and content during the long periods we spend indoors but also increase our awareness of our interdependence with the natural world" (p. 3).

The satisfying experience of weather is often associated with small-scale construction, but it can also be designed into larger-scale buildings. Strategies for enhancing exposure to weather include operable windows, views, porches, balconies, decks, terraces, courtyards, and other inside and outside connections to the outdoor environment. Transparent roofs, rainwater collectors and spouts, visible storm runoff, the sound of wind, and the movement of water can also enhance a greater awareness of meteorological conditions. Simulating the experience of weather can be the product of manipulating sunlight, airflow, humidity, temperature, and barometric pressure.

Figure 3.10. Ponta dos Ganchos resort in Brazil incorporates several biophilic design attributes that enhance its appeal. These include reminders of the intimate relationship of land and sea, striking ocean views, an abundance of natural materials, close connection between the interior and exterior outside environments, and areas of prospect and refuge.

Figure 3.11. The glass house near Tokyo designed by Kengo Kuma powerfully links the building's interior with its exterior setting. The prominence of water, natural lighting and ventilation, and a feeling of connection to weather further enhance this biophilic effect.

8. *Views*

A view of nature is a frequently employed strategy for enriching a sense of contact between people and the natural world. These sights can enrich a distant horizon: consider the prominent landscape features of a seashore, mountain, or an unusual stand of trees. Yet despite its importance and appeal, this form of contact between people and nature can also be limiting in terms of engagement and immersion. For a view of nature to be deeply satisfying and beneficial, it often needs to simultaneously engage people in complementary ways.

Views of nature generally exert their greatest impact when they are at relatively moderate to short distances, at modest heights, and from sheltered spaces. Even the view of a beautiful natural setting can be undermined by an excessively high viewing area, especially when that location lacks an external ledge, shelf, or projection that could mitigate the transition from a high inside view to a steep sweeping outside environment. Many people harbor ambivalent feelings about great heights; in fact, a fear of heights is a common phobia, along with such other environmental aversions as snakes, spiders, bees, and lightning. Great heights can yield awe-inspiring views, but also foster anxiety and intimidation. These adverse effects can be reduced by such design strategies as balconies, decks, ledges, and sheltered spaces.

Views of nature should avoid degraded natural systems or artificially created environments, though effective views can also complement and connect with interior spaces that feature a biophilic design. By contrast, a bland and artificial interior at variance with a beautiful outside view can frequently be dissatisfying and frustrating.

The power of a beautiful view of nature is reflected in the connections among materials, water, and the viewscape at the Fregate Island Resort in the Seychelles (Figures 3.12, 3.13).

9. *Fire*

Fire may seem like an odd attribute of direct biophilic design since its occurrence is typically the consequence of deliberate human intervention and it is often associated with environmental harm and destruction. Natural fires—caused by lightning, volcanic action, and other forms of spontaneous combustion—are often perceived as a destructive force. Despite these misgivings, the exploitation and control of fire represents one of the most significant developments in human history, one that fundamentally distinguished us from other life. The progressive control of fire became the basis for the human production of energy, food, heat, and light as it transformed resources from one state into another. The awareness and response to fire consequently became deeply embedded in the human consciousness. An inherent human affinity for fire emerged not only as a practical necessity, but also as a powerful facet of human imagination and creativity.

But contemporary life and the modern built environment have largely obscured and marginalized the experience of fire. Its vital significance has frequently receded from our awareness. We may enjoy the occasional sight and comfort of a fireplace, although this form of contact with nature has become largely decorative, but in most large-scale modern construction, the experience of fire is rarely evident.

The actual and symbolic experience of fire, nonetheless, continues to generate significant satisfaction and benefits. Beyond the actual sight of fire, its appearance can be suggested by the presence of hearth-like areas that encourage relaxation and intimacy. Certain shapes and colors that add vitality to building forms, fabrics, and other interior design can suggest the qualities of fire. We can further enhance an awareness and appreciation of fire by making it more visible and recognizable in the built environment. For example, rather than concealing the properties of fire associated with heating, cooking, and energy production, these benefits can be rendered more explicitly apparent.

The powerful appeal of a fireplace consisting of wood or stone is revealed in Figures 3.14 and 3.15.

## II. Indirect Experience of Nature

### 10. *Images*

Images of nature are an ancient means for bringing the likeness of the natural world into the built environment. Images of nature in building interiors can be traced back to the cave paintings of Spain's Altamira and of France's Chauvet and Lascaux caverns, the petroglyphs of Australia and India, and other early imagery. The actual and fanciful depiction of nature has long exerted lasting and profound impressions. The anthropologist and veterinarian Elizabeth Lawrence (1993), reflecting on the importance of such symbolic images, observed: "The human need for metaphorical expression finds its greatest fulfillment through reference to [nature and especially] the animal kingdom. No other realm affords such vivid expression of symbolic concepts" (p. 113).

Powerful examples of images and likenesses of nature that enhance our exposure to the natural world include the Norwich Cathedral Rectory in Norwich, England, a wooden door of the Bristol Cathedral, and a traditional Japanese interior (Figures 3.16, 3.17, 3.18).

Literal and metaphorical images of nature are often encountered in civic, educational, and religious architecture. Images of plants, animals, water, landscapes, and geological features continue to be common forms of contact between people and nature in the built environment. Although many contemporary sterile, lifeless buildings lack even this degree of exposure with nature, such images remain a frequently used strategy for enhancing contact with nature, sometimes even by employing the media of photography, computer, and video. Studies have revealed that the more isolated people are from nature

Figure 3.14. The Post Ranch Inn in Big Sur, California, largely designed by Mickey Muennig, contains various biophilic features that largely account for its attraction and success. These include the extensive use of natural materials, views of the nearby ocean, fireplace and hearth-like settings, prominent elements of prospect and refuge, a feeling of connection to the ecology of place, and the use of natural geometries.

Figure 3.15. This fireplace in a home on Martha's Vineyard, Massachusetts, designed by Lew French, combines natural materials, particularly wood and stone, to create a comforting and aesthetically pleasing effect. The intimacy provided by the fireplace and hearth is reinforced by the use of local natural materials and the structure's overall design.

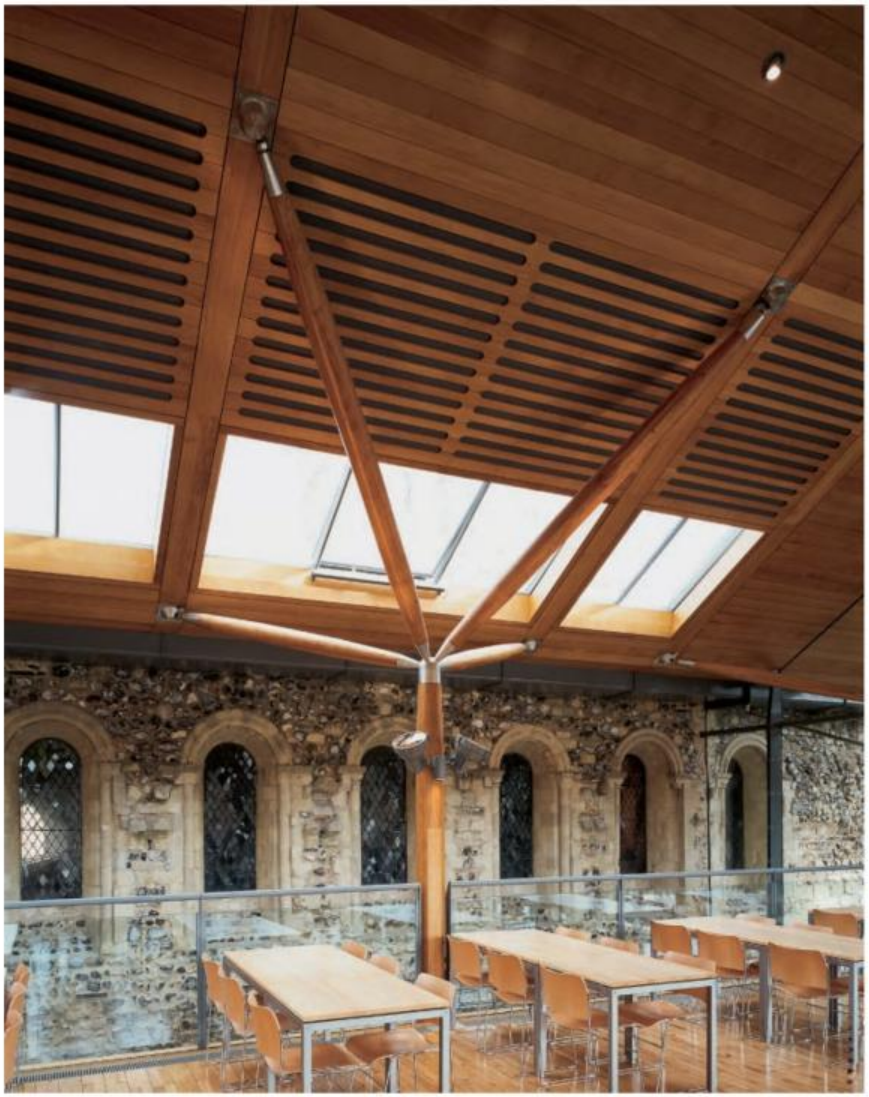

Figure 3.16. The renovated rectory dining area at Norwich Cathedral, Norwich, England, designed by Michael Hopkins Architects, employs several biophilic design strategies to enhance its appeal. These include a reliance on natural materials, especially juxtaposed wood and stone, natural geometries, organized complexity, and a feeling of connection to place.

Figure 3.17. This interior wooden church door at Bristol Cathedral in Bristol, England, is especially pleasing. Its effect stems from such biophilic features as wood carvings and natural color contrasts. Organic shapes and sinuous natural geometries further inspire the carved images.