BIOPHILIC DESIGN
Improving Health & Well-Being in the Built Environment
“Biophilia...

is the innately emotional affiliation of human beings to other living organisms....

Life around us exceeds in complexity and beauty anything else humanity is ever likely to encounter.”

Edward O. Wilson
The Biophilia Hypothesis
GREEN HELPS PEOPLE HEAL
ULRICH STUDY, 1984

A view to nature equals...
• Shorter hospital stays
• Fewer negative comments
• Fewer strong analgesics
VISUAL RESPONSE
KAHN ET AL. STUDY, 2008

Kahn et al. found that...
- Views to nature through a glass window lowered blood pressure faster than a view to fake nature via a digital window (video/plasma) or no window at all.
- Views to fake nature (artwork) are more beneficial than no view.

Physiological benefits to viewing real nature are greater than the benefits of viewing simulated nature.
Physical and virtual exposure to biophilic vs. non-biophilic indoor environments

**Significant Findings**

- Lower blood pressure
- Lower skin conductance level
- Improved short-term memory
- Decreased negative emotions and increased positive emotions reported

**Similar effects for both physical and virtual exposure**

*Figure.* Test environments and physical vs. virtual exposure. A: biophilic environment with physical exposure; B: biophilic environment with virtual exposure; C: non-biophilic environment with physical exposure; D: non-biophilic environment with virtual exposure.
SHINRIN-YOKU “FOREST BATHING”
BUM PARK, 2010 & QING LI, 2010

In natural environments compared to urban environments, subjects had...
- reduced pulse rate
- reduced systolic blood pressure
- reduced cortisol levels
- increased immune function

![Graphs and diagrams related to forest bathing effects](image-url)
“...the enjoyment of scenery employs the mind without fatigue and yet exercises it, tranquilizes it and yet enlivens it;

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

Frederick Law Olmsted, 1865
Introduction to Yosemite and the Mariposa Grove: A Preliminary Report
“Directed attention fatigue” limits ability to focus on a task at hand.

Time spent viewing Nature can reduce mental fatigue and improve concentration.
Figure. Boxplot of the median and variance of moment-to-moment response variability (reported as power). Participants viewed a concrete (orange boxes) or green (green boxes) roof. Data shown for the 1st and 2nd half baseline task, and the 1st and 2nd half post-treatment task indicates a significant difference between participants viewing a concrete and green roof. Source: Lee et al. 40-second green roof views sustain attention: The role of micro-breaks in attention restoration. *Journal of Environmental Psychology 42*(2015):182–189.
Freeway and Beach Frequency Spectra and Logarithmic Averages

Freeway and beach frequency spectra, and their logarithmic average. The averaged spectrum was employed in the experiment. Photographic inserts are stills from typical movies used in the behavioural and scanning studies.

The perception of a water sound as natural was significantly correlated with improving tranquility.

**Figure.** Average tranquility ratings based on all 4 experiments together with fraction categorised as natural and man-made.

*Photo Courtesy of Anvesh Upadhyay.*
**FRACTALS & VISUAL RESPONSE**
SALINGAROS, 2012; TAYLOR, 2006; HÄGERHALL ET AL., 2008; JOYE, 2005

**Key takeaways...**
- Fractal patterns encourage perceptual rather than cognitive thinking.
- Humans have a preference for patterns with a moderate fractal dimension like that found and processed in nature.
- Moderate fractal dimensions are perceived as are most restorative and relaxing.
- High fractal dimensions can engender stress in some people, or creativity in others.
Fractal images were rated as significantly more visually interesting and visually preferred than non-fractal images.

Visual interest peaked at higher complexity levels (D=1.5–1.7) than visual preference (D=1.5).

Distance from projected fractals did not affect visual interest or preference.

Figure. Mean percentage chosen for visual interest and preference by fractal complexity.

Figure. The two highlighted regions are different in terms of bluriness for the fractal shadow of G = 1.7.

Figure. Test images. Four fractals of varying fractal complexity (D1.1–1.7) as well as two non-fractal images (Rectangle and Stripes) shown as part of a rendering (top) and as light projected onto a wall (bottom).
BIOPHILIC DESIGN

Improving Health and Well-Being in the Built Environment
THE IMPACT OF BIOPHILIC DESIGN ON STUDENT SUCCESS
GREEN STREET ACADEMY, BALTIMORE

Objective: to determine the contribution of biophilic design to 6th grade student’s stress reduction and academic performance

Biophilic Classroom includes:
- Biomorphic Forms & Images
- Views to Nature
- Dynamic & Diffuse Light

Measured:
- Stress
- Learning Outcomes
- Subjective Response

Control Classroom. GREEN STREET ACADEMY, BALTIMORE, MD © Craig Gaulden Davis Architects

2017/02/06
THE IMPACT OF BIOPHILIC DESIGN ON STUDENT SUCCESS
GREEN STREET ACADEMY, BALTIMORE

LEARNING OUTCOMES

The Average Test Score Gain is 3.3x Higher in the Biophilic Classroom

Biophilic Classroom, GREEN STREET ACADEMY, BALTIMORE, MD © Craig Gaulden Davis Architects

PROJECT EXAMPLES

Green Street Academy Study
Green Spaces and Cognitive Development in Primary Schoolchildren
Dadvand et al., 2015

- 2593 schoolchildren from 36 schools in grades 2-4
- Looked at greenness in surrounding home, community, and school
- Beneficial association of greenspace and cognitive development

Figure: Twelve-month progress in superior working memory for participants with the first and third tertiles of greenness within the school boundaries.
**Access to Nature**
(Proximity to Greenspace)

- Reduces blood glucose by 40%
  - From exercising outdoors
  - Versus only 21% from exercising indoors

- Increases potential retail sales up to 15% specialty shopping
  - Up to 20% convenience shopping
  - Up to 25% general shopping

**Views to Nature**
(A view of greenspace from inside)

- Shortens hospital stays by 8.5%
- Nationwide savings could be $93M

- Increases property values 30%
  - 59% full ocean view
  - 127% lakefront location

- Improves employee productivity
- Annual savings $3K per employee
- $1000 cost per employee to reorganize workspace

Bottom Line Benefits of Biophilia.
Numbers are rounded to nearest whole. © Bill Browning/GreenSource Magazine

**Economics of Biophilia**
Designing with nature in mind makes financial sense.
CONSTRUCTS OF BIOPHILIC DESIGN

Nature in the Space
Plants, water, and animals in the built environment

Natural Analogues
Objects, materials, and patterns that evoke nature

Nature of the Space
Differing spatial configurations of the built environment

BIOPHILIC DESIGN
Improving Health and Well-Being in the Built Environment
14 Patterns of Biophilic Design

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

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

Nature Of The Space
11. Prospect
12. Refuge
13. Mystery
14. Risk
VISUAL CONNECTION W/ NATURE

NON-VISUAL CONNECTION W/ NATURE

NON-RHYTHMIC SENSORY STIMULI

PRESENCE OF WATER

DYNAMIC & DIFFUSE LIGHT

THERMAL & AIRFLOW VARIABILITY

CONNECTION W/ NATURAL SYSTEMS

See “14 Patterns of Biophilic Design” publication for photo credits, unless otherwise noted.
<table>
<thead>
<tr>
<th>14 PATTERNS</th>
<th>STRESS REDUCTION</th>
<th>COGNITIVE PERFORMANCE</th>
<th>EMOTION, MOOD &amp; PREFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Connection w/ Nature</td>
<td>Lowered blood pressure and heart rate</td>
<td>Improved mental engagement/attentiveness</td>
<td>Positively impacted attitude and overall happiness</td>
</tr>
<tr>
<td>Non-Visual Connection w/ Nature</td>
<td>Reduced systolic blood pressure and stress hormones</td>
<td>Positively impacted cognitive performance</td>
<td>Perceived improvements in mental health and tranquility</td>
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<tr>
<td>Non-Rhythmic Sensory Stimuli</td>
<td>Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity</td>
<td>Observed and quantified behavioral measures of attention and exploration</td>
<td></td>
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<tr>
<td>Thermal &amp; Airflow Variability</td>
<td>Positively impacted comfort, well-being and productivity</td>
<td>Positively impacted concentration</td>
<td>Improved perception of temporal and spatial pleasure (allosthesia)</td>
</tr>
<tr>
<td>Presence of Water</td>
<td>Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure</td>
<td>Improved concentration and memory restoration; Enhanced perception and psychological responsiveness</td>
<td>Observed preferences and positive emotional responses</td>
</tr>
<tr>
<td>Dynamic &amp; Diffuse Light</td>
<td>Positively impacted circadian system functioning; Increased visual comfort</td>
<td></td>
<td></td>
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<tr>
<td>Connection w/ Natural Systems</td>
<td></td>
<td>Enhanced positive health responses</td>
<td>Shifted perception of environment</td>
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<tr>
<td>Biomorphic Forms &amp; Patterns</td>
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<td></td>
<td>Observed view preference</td>
</tr>
<tr>
<td>Material Connection w/ Nature</td>
<td></td>
<td>Decreased diastolic blood pressure; Improved creative performance</td>
<td>Improved comfort</td>
</tr>
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<td>Complexity &amp; Order</td>
<td>Positively impacted perceptual and physiological stress responses</td>
<td></td>
<td>Observed view preference</td>
</tr>
<tr>
<td>Prospect</td>
<td>Reduced stress</td>
<td>Reduced boredom, irritation, fatigue</td>
<td>Improved comfort and perceived safety</td>
</tr>
<tr>
<td>Refuge</td>
<td></td>
<td>Improved concentration, attention and perception of safety</td>
<td></td>
</tr>
<tr>
<td>Mystery</td>
<td></td>
<td></td>
<td>Induced strong pleasure response</td>
</tr>
<tr>
<td>Risk/Peril</td>
<td></td>
<td></td>
<td>Resulted in strong dopamine or pleasure responses</td>
</tr>
</tbody>
</table>
What are the main drivers?
- Desired health outcomes or health and wellbeing goals
- User type/group
- Space programming
- Local climate and ecosystem
- Local culture or heritage
- Environmental goals
- What’s ‘free’ on site
- What’s already measured
12,121 sf architecture office
3,600 sf greenroof
Completed in 2006
LEED Commercial Interior

Main Biophilic Patterns

- [P1] Visual Connection w/ Nature
- [P3] Non-Rhythmic Sensory Stimuli
- [P6] Biomorphic Forms & Patterns
- [P8] Prospect

641 AVENUE OF THE AMERICAS, COOKFOX ARCHITECTS © COOKFOX
14 Patterns of Biophilic Design
EVALUATION
POST-OCCUPANCY SURVEY

- 98% reported that it is important or highly important that their company show concern for the environment
- 86% desired views of the outdoors
- Many reported having “views of long distance vistas”
- 45% cited the green roof as one of their favorite parts of the office
- 42% reported being highly unsatisfied with available “space to unwind”

Workspaces with the lowest visual connection with nature reported the highest work-related stress
Observational study of user trends in biophilic and comparable conventional hotel lobbies

- Sample of **6 hotels** in Midtown Manhattan
- All guests present were counted as either **active or passive users**, or **transient**
- All lobbies were observed at **morning, midday, and evening**

On average, biophilic lobbies saw a 36% use rate while conventional hotels saw only 25%
GUEST EXPERIENCE OBSERVATIONAL STUDIES
DATA BASED ON PROPERTY DESCRIPTIONS FROM 6 HOTELS WEBSITES AND 10 MOST RECENT TRIPADVISOR REVIEWS FOR EACH HOTEL

- Biophilic Property: Website vs. TripAdvisor Reviews
  - Marketing of Biophilic Hotels
  - Reported Guest Experience

- Description Property Website Emphasis
  - Design & Decor
  - Experience
  - Maintenance & Service
  - Location
  - Views
  - Amenities
  - Comfort & Home
  - Ecological & Social Issues

- Conventional Property: Website vs. TripAdvisor Reviews
  - Guest Reviews for Conventional Hotels Emphasized Convenience Over Design & Decor.

Source: Human Spaces 2.0: Biophilic Design in Hospitality (2017)
“...life is more like a verb. It repairs, maintains, re-creates, and outdoes itself.”

– Lynn Margulis and Dorion Sagan, 1995

Blue Morpho Butterfly Wing © Thanushi Eagele/Flickr