



## Document Control

Rev	Date	By	Comments
	08.07.19	S. Peacock	

## Design Guidance

1. Biophilic Design Guide – for designing human centric spaces at The University of Leicester.
2. Biophilia is humankind’s innate biological connection with nature, this can be organised into three categories – Nature in the Space, Natural Analogues and Nature of the Space. This is to enable a framework of understanding and enable incorporation into the built environment. These are presented as 14 Patterns of Biophilic Design.
3. These Patterns are to be applied to the design of new and refurbished spaces at The University of Leicester; to promote and improve well-being, reduce stress, improve cognitive function and creativity and to create a campus which demonstrates our commitment to the well-being of our students, staff and visitors.
4. The Biophilic Patterns should be used which are most relevant to the proposed function and aim of each space, it is not expected that each project would contain all Patterns.
5. This paper provides additional detail, and links to references for further information, for each of the Patterns. Providing examples of how each pattern naturally occurs and suggestions for how each response could be simulated or constructed within the built environment.

### 14 Patterns of Biophilic Design:

#### 6. DIRECT CONNECTION;

##### Direct Connection

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



## Design Guidance

### 7. INDIRECT – NATURAL ANALOGUES

#### Indirect – natural analogues

- 8. Biomorphic forms & patterns
- 9. Material connection with nature
- 10. Complexity and order

### 8. HUMAN SPATIAL RESPONSE

#### Human Spatial response

- 11. Prospect
- 12. Refuge
- 13. Mystery
- 14. Peril

9. Information within the following tables, and further information and guidance on 14 Patterns of Biophilic Design, can be found at; <https://www.terrapinbrightgreen.com/reports/14-patterns/>

### Direct Connection;

Designing in direct contact with nature or direct experience of natural systems.

1. **Visual Connection with Nature;** A view to elements of nature, living systems and natural processes.
2. **Non-Visual Connection with Nature;** Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.
3. **Non-Rhythmic Sensory Stimuli;** Elements in a design which include movement for visual stimuli to be caught in people's peripheral vision.
4. **Thermal & Airflow Variability;** Subtle changes in air temperature, relative humidity, airflow across the skin and surface temperatures that mimic natural environments.
5. **Presence of Water;** A condition that enhances the experience of a place through seeing, hearing or touching water.
6. **Dynamic & Diffuse Light;** Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature.
7. **Connection with Natural Systems;** Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.



## Design Guidance

### \*Naturally Occurring:

### Simulated or Constructed:

#### 1. Visual Connection with Nature

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

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

#### 2. Non-Visual Connection with Nature

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

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

#### 3. Non-Rhythmic Sensory Stimuli

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

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



## Design Guidance

### 4. Thermal & Airflow Variability

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|---|---|
| <ul style="list-style-type: none"> <li>• Solar heat gain</li> <li>• Shadow and shade</li> <li>• Radiant surface materials</li> <li>• Space/place orientation</li> <li>• Vegetation with seasonal densification</li> </ul> | <ul style="list-style-type: none"> <li>• HVAC delivery strategy</li> <li>• Systems controls</li> <li>• Window glazing and window treatment</li> <li>• Window operability and cross ventilation</li> </ul> |
|---|---|

### 5. Presence of Water

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>• River, stream, ocean, pond, wetland</li> <li>• Visual access to rainfall and flows</li> <li>• Seasonal arroyos</li> </ul> | <ul style="list-style-type: none"> <li>• Water wall</li> <li>• Constructed water fall</li> <li>• Aquarium</li> <li>• Fountain</li> <li>• Constructed stream</li> <li>• Reflections of water (real or simulated) on another surface</li> <li>• Imagery with water in the composition</li> </ul> |
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### 6. Dynamic & Diffuse Light

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|--|---|
| <ul style="list-style-type: none"> <li>• Daylight from multiple angles</li> <li>• Direct sunlight</li> <li>• Diurnal and seasonal light</li> <li>• Firelight</li> <li>• Moonlight and star light</li> <li>• Bioluminescence</li> </ul> | <ul style="list-style-type: none"> <li>• Multiple low glare electric light sources</li> <li>• Illuminance</li> <li>• Light distribution</li> <li>• Ambient diffuse lighting on walls and ceiling</li> <li>• Day light preserving window treatments</li> <li>• Task and personal lighting</li> <li>• Accent lighting</li> <li>• Personal user dimming controls</li> <li>• Circadian colour reference (white light during the day and lack of blue light at night)</li> <li>• Colour tuning lighting that produces white light during the day, and minimizes blue light at night</li> </ul> |
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### 7. Natural Systems

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|--|---|
| <ul style="list-style-type: none"> <li>• Climate and weather patterns (rain, hail, snow; wind, clouds, fog; thunder, lightning)</li> <li>• Hydrology (precipitation, surface water flows and resources; flooding, drought; seasonal arroyos)</li> <li>• Geology (visible fault lines and fossils; erosion, shifting dunes)</li> <li>• Animal behaviours (predation, feeding, foraging, mating, habitation)</li> <li>• Pollination, growth, aging and decomposition (insects, flowering, plants)</li> <li>• Diurnal patterns (light colour and intensity; shadow casting; plant receptivity; animal behaviour; tidal changes)</li> <li>• Night sky (stars, constellations, the Milky Way) and cycles (moon stages, eclipses, planetary alignments, astronomical events)</li> <li>• Seasonal patterns (freeze-thaw; light intensity and colour; plant cycles; animal migration; ambient scents)</li> </ul> | <ul style="list-style-type: none"> <li>• Simulated daylighting systems that transition with diurnal cycles</li> <li>• Wildlife habitats (e.g., birdhouse, honeybee apiary; hedges, flowering vegetation)</li> <li>• Exposure of water infrastructure</li> <li>• Step wells for seasonal rainwater storage and social convergence</li> <li>• Natural patina of materials (leather, stone, copper, bronze, wood)</li> </ul> |
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## Design Guidance

### Indirect Experience of Nature;

Design strategies that use references to, or representation of, nature.

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

*Decor:	Form / Function:
<b>8.. Biomorphic forms and patterns</b>	
<ul style="list-style-type: none"> <li>● Fabrics, carpet, wallpaper designs based on Fibonacci series or Golden Mean</li> <li>● Window details: trim and mouldings, glass colour, texture, mullion design, window reveal detail</li> <li>● Installations and free-standing sculptures</li> <li>● Furniture details</li> <li>● Woodwork, masonry</li> <li>● Wall decal, paint style or texture</li> </ul>	<ul style="list-style-type: none"> <li>● Arrangement of the structural system (e.g., columns shaped like trees)</li> <li>● Building form</li> <li>● Acoustic panelling (wall or ceiling)</li> <li>● Railings, banisters, fencing, gates</li> <li>● Furniture form</li> <li>● Window details: frit, light shelves, fins</li> <li>● Pathway and hallway form</li> </ul>
<b>9. Material connection with Nature</b>	
<ul style="list-style-type: none"> <li>● Accent details (natural wood grains; leather; stone, fossil textures; bamboo, rattan, dried grasses)</li> <li>● Interior surfaces (veneer, countertops)</li> <li>● Woodwork, stonework</li> <li>● Natural colour palette, particularly greens</li> </ul>	<ul style="list-style-type: none"> <li>● Wall construction (wood, stone)</li> <li>● Structural systems (heavy timber beams)</li> <li>● Façade material</li> <li>● Furniture form</li> <li>● Footpaths, bridges</li> </ul>
<b>10. Complexity and order</b>	
<ul style="list-style-type: none"> <li>● Wallpaper and carpet design</li> <li>● Material texture and contour</li> <li>● Window details: trim and mouldings, glass colour, texture, mullion design, window reveal detail</li> <li>● Plant selection variety and placement</li> <li>● Complex plant oil fragrances</li> <li>● Auditory stimuli</li> </ul>	<ul style="list-style-type: none"> <li>● Exposed structure/exoskeleton</li> <li>● Exposed mechanical systems</li> <li>● Façade materials</li> <li>● Façade, spandrel and window hierarchy</li> <li>● Building skyline</li> <li>● Floor plan, landscape plan, urban grid</li> <li>● Pedestrian and traffic flows</li> <li>● Resource flows</li> </ul>



## Design Guidance

### Human Spatial response;

Mimicking the spatial qualities of natural environments to evoke/enhance human responses.

11. **Prospect;** Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature.
12. **Refuge;** Materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place.
13. **Mystery;** Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.
14. **Risk/Peril;** A space with a good Risk/Peril condition feels exhilarating. The objective of the Risk/Peril pattern is to arouse attention and curiosity, and refresh memory and problem solving skills.

*Decor:	Form / Function:
<b>11. Prospect</b>	
<ul style="list-style-type: none"> <li>● Focal lengths <math>\geq 6</math> metres</li> <li>● Partition heights <math>\leq 1</math> m (hedges; opaque workplace partitions)</li> </ul>	<ul style="list-style-type: none"> <li>● Transparent materials</li> <li>● Balconies, catwalks, staircase landings</li> <li>● Open floor plans</li> <li>● Elevated planes</li> <li>● Views including shade trees, bodies of water or evidence of human habitation</li> </ul>
Spatial Attributes:	Common Features:
<b>12. Refuge</b>	
<ul style="list-style-type: none"> <li>● Modular refuge: Small protection (high-back chair, overhead trellis)</li> <li>● Partial refuge: Several sides covered (reading nooks, booth seating, bay window seats, canopy beds, gazebos, canopy trees, arcades, covered walkways or porches)</li> <li>● Extensive refuge: near or complete concealment (reading/telephone/sleeping pods, meeting rooms with 3+ walls, private offices, tree houses)</li> </ul>	<ul style="list-style-type: none"> <li>● Spaces with weather/climate protection, or speech and visual privacy</li> <li>● Spaces reserved for reflection, meditation, rest, relaxation, reading, or complex cognitive tasks</li> <li>● Operable, adjustable or translucent (or semi-opaque) shades, blinds, screens or partitions</li> <li>● Drop or lowered ceiling or soffit, overhang or canopy</li> <li>● Lowered or varied light colour, temperature or brightness</li> </ul>
<b>13. Mystery</b>	
<ul style="list-style-type: none"> <li>● Views are medium (<math>\geq 6</math> m.) to high (<math>\geq 30</math> m.) depth of field</li> <li>● At least one edge of the focal subject is obscured, preferably two edges</li> <li>● Auditory stimulation from an imperceptible source</li> <li>● Peek-a-boo windows that partially reveal</li> <li>● Curving edges</li> <li>● Winding paths</li> </ul>	<ul style="list-style-type: none"> <li>● Light and shadow</li> <li>● Sound or vibration</li> <li>● Scent</li> <li>● Activity or movement</li> <li>● Artwork or installation</li> <li>● Form and flow</li> <li>● Translucent materials</li> </ul>



## Design Guidance

### 14. Risk/Peril

#### Spatial Attributes:

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

- Double-height atrium with balcony or catwalk
- Architectural cantilevers
- Infinity edges
- Façade with floor-to-ceiling transparency

#### Perceived Risks:

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

- Experiences or objects that are perceived to be defying or testing gravity
- Transparent railing or floor plane
- Passing under, over or through water
- Proximity to an active honeybee apiary or predatory animals
- Life-sized photography of spiders or snakes

### Colour:

Colour to be used within interiors with consideration to the atmosphere and use of each space.

Object and colour association – a concept that Palmer and Schloss (2010) have called the “*ecological valence theory*” suggests that people are naturally more attracted to significant everyday objects that tend to provoke positive emotions.

<https://blog.interface.com/en-uk/ecological-valence-theory-use-color-design/>



**Blues and cyan:**  
calm and relaxation

**Green:**  
calm and creativity

**Yellow and orange:**  
energy and happiness

**Red:** excitement and  
concentration



## Design Guidance

### Further Information and Guidance on Biophilic Design and its implementation:

- Interface\_Creating Positive Spaces Using Biophilic Design;

[http://interfaceinc.scene7.com/is/content/InterfaceInc/Interface/EMEA/eCatalogs/Brochures/Biophilic%20Design%20Guide/English/ec\\_eu-biophilicdesignguide-en.pdf?utm\\_campaign=EMEA\\_UK\\_EN\\_18\\_Q3\\_Biophilic%20Design%20Guide&utm\\_medium=email&utm\\_source=Eloqua](http://interfaceinc.scene7.com/is/content/InterfaceInc/Interface/EMEA/eCatalogs/Brochures/Biophilic%20Design%20Guide/English/ec_eu-biophilicdesignguide-en.pdf?utm_campaign=EMEA_UK_EN_18_Q3_Biophilic%20Design%20Guide&utm_medium=email&utm_source=Eloqua)

- Terrapin Bright Green\_14 Patterns of Biophilic Design, Improving Health & Well-Being in the Built Environment;

*\*Information within tables, and further information and guidance on 14 Patterns of Biophilic Design;*

<https://www.terrapinbrightgreen.com/reports/14-patterns/>

<http://www.terrapinbrightgreen.com/wp-content/uploads/2014/04/14-Patterns-of-Biophilic-Design-Terrapin-2014e.pdf>

- Oliver Heath Design

<https://www.oliverheath.com/biophilic-design-connecting-nature-improve-health-well/>

### Appendix 1. Biophilic Design Patterns & Biological Responses:

Table from Pg. 12. <http://www.terrapinbrightgreen.com/wp-content/uploads/2014/04/14-Patterns-of-Biophilic-Design-Terrapin-2014e.pdf>

Illustrates the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement and the human body. Patterns that are supported by more rigorous empirical data are marked with three asterisks (\*\*\*) , indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicated that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern.





## Design Guidance

## Appendix 1. Biophilic Design Patterns &amp; Biological Responses:

14 PATTERNS	*	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	<ul style="list-style-type: none"> <li>Lowered blood pressure and heart rate (Brown, Barton &amp; Gladwell, 2013; van den Berg, Hartig, &amp; Staats, 2007; Tsunetsugu &amp; Miyazaki, 2005)</li> </ul>	Improved mental engagement/ attentiveness (Biederman & Vessel, 2006)	Positively impacted attitude and overall happiness (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	<ul style="list-style-type: none"> <li>Reduced systolic blood pressure and stress hormones (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)</li> </ul>	Positively impacted on cognitive performance (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundstrom, 2004)	Perceived improvements in mental health and tranquility (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	<ul style="list-style-type: none"> <li>Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)</li> </ul>	Observed and quantified behavioral measures of attention and exploration (Windhager et al., 2011)	
	Thermal & Airflow Variability	<ul style="list-style-type: none"> <li>Positively impacted comfort, well-being and productivity (Heerwagen, 2006; Tham &amp; Willem, 2005; Wigo, 2005)</li> </ul>	Positively impacted concentration (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	Improved perception of temporal and spatial pleasure (alliesthesia) (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	<ul style="list-style-type: none"> <li>Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure (Alvarsson, Wiens, &amp; Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman &amp; Vessel, 2006)</li> </ul>	Improved concentration and memory restoration (Alvarsson et al., 2010; Biederman & Vessel, 2006) Enhanced perception and psychological responsiveness (Alvarsson et al., 2010; Hunter et al., 2010)	Observed preferences and positive emotional responses (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphries et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	<ul style="list-style-type: none"> <li>Positively impacted circadian system functioning (Figueiro, Brons, Plitnick et al., 2011; Beckett &amp; Roden, 2009)</li> <li>Increased visual comfort (Elyezadi, 2012; Kim &amp; Kim, 2007)</li> </ul>		
	Connection with Natural Systems			Enhanced positive health responses; Shifted perception of environment (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns	*		Observed view preference (Vessel, 2012; Joye, 2007)
	Material Connection with Nature		Decreased diastolic blood pressure (Tsunetsugu, Miyazaki & Sato, 2007) Improved creative performance (Lichtenfeld et al., 2012)	Improved comfort (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	<ul style="list-style-type: none"> <li>Positively impacted perceptual and physiological stress responses (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)</li> </ul>		Observed view preference (Salingaros, 2012; Hägerhall, Laike, Taylor et al., 2008; Hägerhall, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	Prospect	<ul style="list-style-type: none"> <li>Reduced stress (Grahn &amp; Stigsdotter, 2010)</li> </ul>	Reduced boredom, irritation, fatigue (Clearwater & Coss, 1991)	Improved comfort and perceived safety (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge	<ul style="list-style-type: none"> <li></li> </ul>	Improved concentration, attention and perception of safety (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery	<ul style="list-style-type: none"> <li></li> </ul>		Induced strong pleasure response (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril	<ul style="list-style-type: none"> <li></li> </ul>		Resulted in strong dopamine or pleasure responses (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

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