Biophilic Railway Stations: 
Re-imagine the Nature of Transit Design

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Abstract

Across the world railway stations, transit centres and transport interchanges are rapidly evolving from purely functional transit spaces to new urban centres and destinations, resulting in activity hubs and gathering places. These stations generate high footfall creating life and vitality, and form the centre of daily routines for many urban dwellers. Train stations are places of connection, they are gateways to the city, and can be one of the most exciting places in an urban environment to experience. Some stations make great destinations with shops, restaurants, museums and exhibition spaces. New architecture for railway stations acknowledges the functions of transit; whilst the heritage of place, culture and the surrounding urban spaces can provide excellent public areas to celebrate our innate human connection to nature. Similar to the grandeur of old railway stations, new majestic spaces with biomorphic-inspired monumental elements can include the fundamental pattern language that underpins the principles of Biophilia.

Rail transport infrastructure, especially railway stations, significantly contributes to the quality of human life, sustainability and the economy of urban centres. Station buildings play a major role in efficient and vibrant places, and can be at the forefront of innovation and modernity. Due to the current unprecedented levels of global urbanization, cities and their governing entities are investing in more sustainable public transport systems. The rationale for this investment is to aid reduction in greenhouse gas emissions and, assist economic efficiencies in goods and people movements across and within cities providing better forms of transport, whilst assisting in the creation of improved sustainability and healthier urban environments. New major transit projects massively impact the city fabric, but also provide opportunities to reshape urban environments to include innovative biophilic design.

This paper investigates the opportunities that new transit hubs and railway stations and their associated infrastructure can provide for creating more sustainable and healthy urban environments, through the lens of Biophilic Design. In the foreword of a recent study Creating Healthy Places (2017, p9), Professor Tim Beatley raises the question, “might we re-imagine the very nature of a transit trip? Could it be not simply a trip to work or a travel to the high street, but perhaps a visit to the forest, a chance to hear and celebrate native birdsong, or a chance encounter with a butterfly. Perhaps food production becomes part of transit design, so that one picks a tomato or a desert plum on the way to catch the train. Why not a transit station in a forest?”
This paper explores the patterns of Biophilia and its application to railway stations. It further benchmarks old and new examples of railway stations across the world against Biophilic patterns, and reflects on the *Creating Healthy Places* (2017) study recently completed for the Metro Tunnel Project in Melbourne, Australia. It concludes with recommendations of key principles to be considered for Biophilia-inspired railway station design that can assist in advancing the larger vision and agenda of ecologically sustainable and Biophilic Cities.

**Keywords:** Biophilia, Biophilic Design, Biophilic Cities, Railway Station Design, Healthy Cities

1. Introduction

Railway stations and rail transport infrastructure contribute significantly to the economy of urban areas, improving quality of life due to availability of public transport, and increasing the sustainability of cities. Station buildings can play a major role in achieving efficiency and creating vibrancy, and are often at the forefront of innovation and modernity. These buildings are also the hubs of many inner city and suburban precincts, acting as transit centres and transport interchanges which are evolving rapidly from purely functional movement spaces to new destinations and gathering places. Some stations make great destinations with shops, restaurants, museums and exhibition spaces, and railway stations can be the gateways to the city [17, p159]. These stations generate high footfall creating life and vitality, and are the centre of daily routines for many urban dwellers [16].

Due to the current unprecedented growth in urbanization, cities and their governance entities invest in more sustainable public transport systems to aid the reduction in greenhouse gas emissions, improve economic efficiencies in goods and people movements in and out and across and within the cities, provide better forms of transport, and assist in creating sustainable and healthy urban environments.

Core to the investments in rail infrastructure is the provision of railway stations. These provide opportunities for a new architecture that acknowledges the functions of transit and the heritage of place and culture, while the surrounding urban spaces can provide excellent public areas to celebrate our innate human connection to nature [21].

Similar to the grandeur of old railway stations, new majestic spaces with biomorphic-inspired elements and the principles of Biophilic Design can include the fundamental pattern language [1] that underpins the principles of Biophilia: humans’ innate connection with nature.
2. The Innate Human-Nature Relationship

In the *Biophilia Hypothesis* (1986), Edward O. Wilson notes that humans need daily contact with nature to be healthy and achieve longevity. His reasoning was that humans have co-evolved with nature and are part of nature, noting that biophilia is “the innately emotional affiliation of human beings to other living organisms. Innate means hereditary, and hence, part of ultimate human nature” [10]. Biophilia supports the proposition that environments around humans need to include the essentials of nature to provide us with psychological and physiological health:

Over thousands of generations the mind evolved within a ripening culture, creating itself out of symbols and tools, and genetic advantage accrued from planned modifications of the environment. The unique operations of the brain are the result of natural selection operating through the filter of culture. They have suspended us between the two antipodal ideas of nature and machine, forest and city, the natural and artifactual, relentlessly seeking, in the words of the geographer Yi-Fu Tuan, an equilibrium not of this world [19, 21].
Affiliation with nature continues to be critical in modern-day human health and wellbeing literature and practice [7], and has been strongly identified as a valid concern by the health sciences. In the research area of human health and wellbeing, a growing body of research reveals that exposure to nature continues to result in positive health benefits in a wide range of sectors; at work, home, recreation, community areas and even within the urban environments where people work and live [3, 9].

While humans may have an inherent affiliation with nature, the benefits as a result of contact of nature depend on repeated exposure to the elements that generate the biophilic effect. This biological tendency needs to be nurtured and developed to become embedded in contemporary metropolitan environments [9, 12]. One method to develop this affiliation is to design places that facilitate the biophilic experience and repeated connections with (real and surrogate) nature in peoples’ daily lives. Dubos acknowledges this opportunity as being the need to re-establish an in-depth and loving relationship between humans and nature:

*The relationship between humankind and nature can be one of respect and love rather than domination ... The outcome ... can be rich, satisfying, and lastingly successful, but only if both partners are modified by their association so as to become better adapted to each other ... With our knowledge and sense of responsibility ... we can create new environments that are ecologically sound, aesthetically satisfying, economically rewarding ... This process of reciprocal adaptation occurs ... through minor changes in the people and their environment, but a more conscious process of design can also take place. - Rene Dubos, The Wooing of the Earth; cited in Kellert & Calabrese, 2015 [11].*

Alexander (1977) strongly argues that this affiliation to nature is needed, and that the fundamentals of a ‘more conscious process of design’ are necessary. In ‘*A Pattern Language*’ (1977), Alexander states:

*People need contact with trees and plants and water. In some way, which is hard to express, people are able to be more whole in the presence of nature, are able to go deeper into themselves, and are somehow able to draw sustaining energy from the life of plants and trees and water. - Pattern 173 ‘Garden Wall’ [1, p806].*

This indicates that psychological benefits for us as humans are deeply rooted in the connections with nature. The fundamental benefits of physiological and psychological wellness due to biophilic exposure are further explored by Kellert (2005), with findings demonstrating numerous health benefits and a better quality of life [8, 12]. These benefits can be achieved if we design and plan our built environments to include the considerations of Wilson’s biophilia, more specially identifying the structures and patterns that occur in the form-making processes of the living systems of nature, and design and plan with a regenerative process that unfolds living environments of place [14, 18].
3. Biophilic Design

To be able to apply the context of biophilia in our daily lives, the concept of Biophilic Design promoted by Kellert et al (2008) and further interpreted and celebrated by Newman (2012) and others, particularly Beatley in Biophilic Cities (2010), must be able to help us establish and nurture healthy and living environments in our cities that supports healing and wellbeing [2, 5, 12].

To establish whether biophilic design can achieve this goal of healing and wellbeing, we first need to identify and understand the meaning of biophilic design. Biophilic design is the deliberate attempt to translate an understanding of the inherent human connection to natural systems and processes, known as ‘Biophilia’ into the design of the built environment [12]. Salingaros (2013) explains that biophilic design involves ‘deep connections’ to nature that include links to geometric structures and patterns that occur in the form-making processes of living systems, resulting in the ‘biophilic effect’ [18, p8].

Further, biophilic design:

... seeks to create good habitat for people as a biological organism in the built...
environment that advances people’s health, fitness and wellbeing [11, p6].

4. Codes and Patterns

Widespread application of biophilic design in practice requires some codification and agreement by practitioners on which design elements produce particular replicable biophilic results [5]. Browning et al (2014) propose 14 Patterns of Biophilic Design (Table 1) within a framework that relates human biological science and nature to the design of the built environment [3]. Their 14 Patterns build upon the inquiries of biophilic researchers over a number of years:

... developed from empirical evidence and interdisciplinary analysis of more than 500 peer-reviewed articles and books [3, p62].

As noted by Downton et al (2017), this research offers both tools for understanding design opportunities [4], and avenues for the application of design as a way to enhance health and well-being at both the individual and societal level (Ryan et al 2014). According to its authors, inspired by Alexander (1977), the term ‘pattern’ is used [1, 3]:

... to propose a clear and standardized terminology for biophilic design; to avoid confusion with multiple terms (metric, attribute, condition, characteristic, typology, etc.) that have been used to explain biophilia; and to maximize accessibility for designers and planners by upholding familiar terminology [3].

Using this strategy, and to apply biophilic design to the built environment in its simplest form, Potteiger & Purinton (1998) and Browning et al (2014) include the following design principles aligned with ‘biophilic patterns’ that can guide design decisions [3, 13]:

Table 1: Principles and Patterns of Biophilic Design

<table>
<thead>
<tr>
<th>Biophilic Design Principles</th>
<th>Patterns of Biophilic Design</th>
<th>Nature of the Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature in the Space</td>
<td>Natural Analogues</td>
<td>Prospect</td>
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<tr>
<td>Natural Connection with Nature</td>
<td>Biomorphic Forms &amp; Patterns</td>
<td>Nature</td>
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<tr>
<td>Non-Visual Connection with Nature</td>
<td>Material Connection with</td>
<td>Refuge</td>
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<tr>
<td>Non-Rhythmic Sensory Stimuli</td>
<td>Nature</td>
<td>Mystery</td>
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<tr>
<td>Presence of Water</td>
<td>Complexity &amp; Order</td>
<td>Risk &amp; Peril</td>
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<tr>
<td>Dynamic &amp; Diffuse Light Connection with Natural Systems</td>
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Of particular interest to the Biophilic City concept is the realisation that some biophilic effects can be achieved with no physical or tangible link to ‘nature’ or living systems at all [4]. Indirect experiences of ‘nature’ or
living systems, which may include artistic representations of nature, virtual reality and other illusions of nature can also generate biophilic psycho-physiological responses. Biophilic effects are measurable in environments at a distance from immediate interaction with nature, such as hospital rooms, when people are exposed to images or illusions of nature such as artificial sky. These kinds of illusory, or virtual, systems are part of a range of design tools available to the biophilic designer [4, 5].

The inclusion of an additional pattern, \textit{Pattern 15 – Virtual Connection to Nature} (Table 2), is predicated on the observation that virtual experience of nature can result in some of the same beneficial effects as ‘real’ experience with human physiological and psychological evidence pointing to stress reduction that lowers blood pressure and heart rate; cognitive performance improvements through mental engagement and attentiveness; and emotions, moods and preferences that positively impact upon human attitudes and overall happiness - Brown, Barton & Gladwell, 2013 cited in [4].

These 15 biophilic design patterns have been recommended to be used in the design of railway stations in \textit{Creating Healthy Places} [4] as follows:

\begin{table}[h]
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\begin{tabular}{|l|l|}
\hline
\textbf{Biophilic Design Pattern} & \textbf{Biophilic Design General Principles} \\
\hline
1. Visual Connection with Nature & A view to elements of nature, living systems and natural processes \\
& Ensure visual access to real presentations of nature throughout the station complexes in preference to simulated nature and non-nature representations \\
\hline
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 \\
& Enhance opportunities for sensory connections (audible, smell, texture, temperature) to nature throughout the station complexes, in preference to urban simulated or constructed representations \\
\hline
3. Non-Rhythmic Sensory Stimuli & Stochastic and ephemeral connections with nature that may be analysed statistically but may not be predicted precisely \\
& Instil patterns of nature’s movements and seasonality throughout the station complexes, using real or artistic representations where necessary \\
\hline
4. Thermal & Airflow Variability & Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments \\
& Consider sequential changes in thermal and airflow variability to refresh spaces and to enable comfortability throughout the station complexes \\
\hline
5. Presence of Water & A condition that enhances the experience of a place through the seeing, hearing or touching of water \\
& Use water as a static, dynamic and or variable design element to achieve multi-sensory experiences throughout the station complexes \\
\hline
6. Dynamic & Diffuse Light & Leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature \\
& Use mixtures of dynamic, diffuse and changeable lighting arrangements and patterns (including illuminance and colour) to evoke movement, time, seasonality, while maximizing solar access throughout the station complexes \\
\hline
7. Connection with Natural Systems & Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem. \\
& Use natural systems (weather, hydrology, geology, terrestrial and aquatic wildlife, diurnal and seasonal patterns) as design inspirations throughout the station complexes \\
\hline
8. Biomorphic Forms & Patterns & Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature. \\
& Ensure biomorphic patterns legibility and interest in floor/ceiling/roof/wall places and furniture detail throughout the station complexes \\
\hline
9. Material Connection with Nature & Consider the richness of material colour, warmth, authenticity and tactility throughout the station complex \\
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\end{tabular}
\caption{Biophilic Design Patterns, Narrative and General Principles}
\end{table}
Material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place.

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Description</th>
<th>Example</th>
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<tbody>
<tr>
<td>10. Complexity &amp; Order</td>
<td>Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.</td>
<td>Prioritise pattern compositional and order use enabling stimulation, interest and legibility, including artwork throughout the station complexes.</td>
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<td>11. Prospect</td>
<td>An unimpeached view over a distance for surveillance and planning.</td>
<td>Provide a sense of arrival, prospect, for each portal ‘gate’, concourse level and platform level for the station complexes.</td>
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<tr>
<td>12. Refuge</td>
<td>A place for withdrawal, from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.</td>
<td>Provide opportunities for retreat, contemplation, waiting, meeting, refuge, for each portal ‘gate’, concourse level and platform level of the station complexes.</td>
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<tr>
<td>13. Mystery</td>
<td>The promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.</td>
<td>Provide a sense of journey in pedestrian environments that ensures sightlines, permeability, and variability in edges and planes.</td>
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<td>14. Risk/Peril</td>
<td>An identifiable threat coupled with a reliable safeguard</td>
<td>Lessen personal risk in preference to safety but do not let safety considerations override Biophilic Design opportunities and principle execution.</td>
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<td>15. Virtual Connection with Nature:</td>
<td>A view to a simulacrum of natural elements, living systems and natural processes</td>
<td>Provide virtual connections with nature viewed through mediated means or evoked by simulacra of nature, living systems and natural processes. Examples include artificial skies, animatronics and portrayal of nature via virtual reality.</td>
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Using these 15 patterns can potentially support and enhance the design of railway stations as noted by Beatley (2017), stating that “Nature in cities, we increasingly recognize, is not something optional, but absolutely essential to leading a happy, healthy and meaningful life. And this extends to the design of every element in the city, including transit stations.” - cited in Downton et al., 2017, p9 [4].

5. Creating Healthy Places - A Case Study

With partnership support from the Melbourne Metro Rail Authority (MMRA), a research team from Deakin University prepared and developed an international technical benchmark study on biophilic design and rail transport infrastructure – *Creating Healthy Places* (2017), to identify the potential opportunities to consider biophilic design in the new Metro Tunnel railway stations [4].

*Creating Healthy Places* (2017) offers biophilic design insights and performance guidelines towards the enrichment of each of the proposed Metro Tunnel Project (MTP) railway stations to provide opportunities for biophilic design to be incorporated in the design process. It also offers avenues and principles that may better address the Project’s sustainability alignment, and achieve certification of the railway stations under the Green Building Council of Australia-Green Star Rating system by supporting the potential targeting and achievement of a 6 Green Star rating for the railway stations [4, p.3].

This research project specifically focuses on two key outcomes:
Interrogation of the biophilia (and urban design quality) possibilities of the 5 new MTP railway stations (Arden, Parkville, CBD North, CBD South, Domain) in terms of their underground concourse areas and vertical circulation area, as well as their above ground plazas, entrances and integration with the larger streetscape and immediate environments, and;

- Contributing practice-rich knowledge and exemplars to inform the Metro Tunnel Project as to key opportunities, issues and ideas for biophilic design formulation of the overall project [4, p13].

The approach taken for the potential application of biophilic design to the railway stations was to firstly align the biophilic design principles and 15 patterns (14+1) with the MMRA Sustainability Policy, secondly, with the MMRA Urban Design Strategy, and thirdly, through a design narrative that matches the patterns with general principles of station design in a priority hierarchy. Finally the ‘Biophilic Design Toolkit’ was applied to provide a summary of recommendations for each station, using 17 actions or recommendations for the application of the biophilic design patterns [4].

6. The Toolkit

The ‘Biophilic Design Toolkit’ is a simple method to align 17 identified biophilic design recommendations/actions (Table 3) to support the application of the 15 biophilic design patterns to railway station complexes and environments (Figure 3). To demonstrate the possible outcomes, the ‘toolkit’ was used to assess exemplar projects indicating the biophilic toolkit qualities evident in the projects [4, pp88-94].

An example of the application of the 17 recommendations (Recommendation 1: Adopt a Biophilic Design Program), is indicated in the following Figure 3.

<table>
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<th>Biophilic Design Toolkit</th>
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7. International Examples

There are very few examples of railway or metro stations that have been designed with the specific intention to evoke biophilia qualities for their users. There are, however, stations that have been designed with elements that are intrinsically biophilic. There are also public sector/infrastructure buildings, urban spaces and landscapes that are strongly biophilic. One notable example of a public infrastructure project is Singapore’s extraordinarily successful and well-visited ‘Gardens by the Bay’, where the specific intention to evoke biophilia is,
arguably, the primary driver of the project. Two examples of railway stations identified in this paper include the Stockholm Metro Stations (Figure 3) and the Atocha Railway Station (Figure 4).

**Stockholm Metro Stations**

The Stockholm Metro is a good example that demonstrate how local character, culture and place-making are celebrated in the distinctiveness of the underground railway stations in contrast to otherwise typically generic and placeless metro station environments [4, p91]. The Stockholm Metro is one gigantic art gallery. More than 90 of the 110 stations feature artworks created by some 150 artists. For the price of a Stockholm Metro ticket you can see sculptures, mosaics, paintings, art installations, inscriptions and reliefs from the 1950’s through to the 2000’s at most metro stations [6].

Using the Biophilic Design Toolkit, an assessment of the Stockholm Metro Stations indicates that the design adopts a biophilic design program (or partially), includes biomorphic forms and elements, use materials as natural analogues, create distinct spatial environments, and makes strong use of public art.

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<th>Biophilic Toolkit Qualities</th>
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*Figure 4: Biophilic patterns in the Kungsträdgården underground metro station, Stockholm. Image Credit: Julian Herzog, 2016* [6].
**Atocha Railway Station**

The Atocha Railway Station’s concourse includes a 4,000m² covered garden arranged in neat garden beds. Around 260 species and over 7,000 plants improve the internal ambience, climate and environmental air quality of the station.

Using the Biophilic Design Toolkit, an assessment of the Atocha Railway Station indicated that the design also adopts a biophilic design program (or partially), includes biomorphic forms and elements, maximises the use of daylight, makes creative use of water within the station complex, and manipulates the soundscape and olfactory landscape to reinforce biophilic effects. Further, the station demonstrates the creation of distinct spatial environments and makes the skyline visible from within.

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**Figure 5:** Atocha Railway Station, Madrid, Spain. Image Credit: Yulia Grogoryeva, 2014.
8. Discussion and Conclusion

This paper proposes a fresh design approach to city infrastructure that demonstrates how biophilic design can bring together the realms of the built environment and nature so that we as humans can experience the wellbeing benefits of biophilia. The Biophilic Design of railway stations provides opportunities to re-imagine the nature of transit design and can assist in the enhancement of urban environments, including the possibilities for extensive vegetation, improvement and enrichment of ecological systems and their communities, and strengthening connections between humans and nature [4, 5].

The *Creating Healthy Places* (2017) study indicated that biophilic design can deliver visual, aural, and thermal stimulation(s) in urban environments, whereby such environments can become living laboratories as exemplars of what future Biophilic Cities could be [4]. However, the designing of cities and urban environments needs to be undertaken with the awareness that the inclusion of biophilia is not only limited to the provision of vegetation, but that biophilic design is a scientifically-informed design method that involves a raft of variables and attributes including environmental features, natural shapes and forms, ecological patterns and processes, light and space, considerations of place-based relationships, and the psychological and physiological evolved human-nature relationships as part of a holistic design solution.

Key to achieving this vision is the use of the *15 Biophilic Design Patterns* [4], supported by a *Biophilic Design Toolkit* applied to city infrastructure design and planning that includes *17 biophilic recommendations/actions*, as well as an accompanying biophilic design narrative [4, 5]. This paper concludes with the following recommendations to be considered for Biophilia-inspired railway station design, which can assist in advancing the larger vision and agenda of Biophilic Cities:

- The need to include the principles of biophilic design in large infrastructure projects of cities to improve the biophilic city agenda;
- Adopt a biophilic design programme for new rail infrastructure projects (similar for other city shaping infrastructure projects);
- Go beyond standard railway station design and use the 15 patterns of biophilic design to inform the architecture, planning and urban design of the stations and their surrounding urban environment and precinct;
- Adopt the 17 actions and recommendations of the *Biophilic Design Toolkit* to integrate the biophilic agenda as a fundamental part of the design programme;
- Make biophilic design a key requirement in the sustainability policies and standards of city planning; and
- Include biophilic design outcomes in the performance requirements for infrastructure design and delivery.

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