

THE OFFICIAL JOURNAL OF AIRAH

JULY 2018 · VOLUME 17.6

RRP \$14.95

PRINT POST APPROVAL  
NUMBER PP352532/00001

# Ecolibrium

## Natural selection

The benefits of  
biophilic design.







# We are nature

Although related, the terms “biomimicry” and “biophilia” mean very different things. Sean McGowan explores the growing influence of biophilia in the built environment with Dr Dominique Hes, M.AIRAH, director of Thrive research hub at the Melbourne School of Design; Tim Angus, associate with design firm Grimshaw; and sustainability consultant and biomimicry specialist Jane Toner.

**Ecolibrium:** We last visited the topic of biomimicry in 2015. As we discussed then, biomimicry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature’s time-tested patterns and strategies. How has the field progressed in the three years since?

**Angus:** The field is definitely gaining momentum. We’re seeing more and more interest and applications in the built environment all the time – it’s an exciting time to be involved.

There is also a reaction against “greenwashing” and more of a realisation of how far away from true sustainability we actually are, and that small linear improvements in our built environment will not get us to where we need to be quick enough. Looking to nature for answers and inspiration seems an increasingly obvious choice, given that nature is an incredible living model of sustainable design.

**Hes:** It is being taken up as a driver for innovation in many engineering and design fields.

**Toner:** Biomimicry is still an emerging discipline, and its underlying premise of “life creating conditions conducive to life” continues to flourish and inspire innovation that goes beyond product design to fields as diverse as social innovation, education, leadership, business, economics and regenerative design.

With advances in 3D printing, computer-aided design and green chemistry, biomimicry is being applied to the development of new materials like anti-bacterial surfaces inspired by insect wings, and more efficient solar panels inspired by butterfly wings. Products like these have a small set of functional requirements so continue to be the most prevalent examples.

The potential for real transformation increases when designers go beyond emulating form and process to thinking at a systems scale, promising new materials supply chains based on nature’s recipes and a circular economy.

When it comes to the built environment, progress is slower – in part because there



Dr Dominique Hes, M.AIRAH

are multiple and many functions to address, but also because there is still a gap in understanding how biomimicry can be brought into the design process.

To this end, I'm writing a book on integrating biomimicry into the built environment to inspire regenerative design solutions.

At a higher level, biomimics are asking how cities can function like the .



Tim Angus

**Eco:** In a practical sense, where are we seeing biomimicry in current building design? What are some good examples?

**Angus:** We're seeing more designers engage creatively with the aerodynamics of buildings. For instance, Brookfield's proposal for an off-grid high-rise in Sydney has been inspired by the aerodynamics of owls' wings to reduce the building's wind loading.



Jane Toner

Along with our own interest in building aerodynamics, Grimshaw is undertaking biomimetic research, which involves studying the solar performance of the branching forms of coral and trees to explore how this may translate into a new high-performance model for our built environment. Grimshaw has also designed high-performance "solar trees" for our Dubai 2020 sustainability pavilion, which capture energy from sunlight and water from the humid air.

**Toner:** There's some great work being done on adaptive, or dynamic, facades that respond to temporal environmental conditions. While much of this work is academic or in development, there are a few examples trickling through to the market.

These include a shading system composed of a series of thin fins with a hingeless opening-closing mechanism inspired by the pollination mechanism of the Bird of Paradise flower. And a facade system by Decker Yeadon that emulates the movement of muscles to expand and contract a shading system in response to heat.

My current favourite is the Breathing Skins technology – a pneumatic facade inspired by the pores and pigment of skin. It consists of an array of inflatable bags with pore-like openings that, in response to internal and external conditions, adjust the permeability of the surface to control the flow of light, humidity, temperature and visibility.

**Eco:** How does biophilia – or biophilic design – differ from biomimicry? Are we right to be confused between the two terms?

**Hes:** There is a big difference between the two.

Biomimicry is learning from nature, while biophilia is our need to be connected to nature.

It's the difference between a researcher looking at improving food production and eating food. Or being a mechanical engineer designing a healthy air conditioning system and being an employee in a healthy building.

Biomimicry asks, for example, how termites condition their space so precisely given the 40°C swing that they experience.

Biophilia asks how we design our environment so that we integrate the benefits of nature – views, plants, animals, colours, and structural and aesthetic references.

The biophilia hypothesis is based on the science that demonstrates the mental and physical benefits of being connected to nature.

**Toner:** The root of both words is “Bios”, the Greek origin of which is life or living organisms, so perhaps that is where the confusion lies.

Biophilia is an innate need that humans have for connection with life and life's processes that stems from our species' immersion in the natural environment for the greater part of our history.

In order to survive and thrive, our ancestors needed to be attuned to the environmental cues and feedback loops of the natural world. It is not surprising that the presence of water reduces stress, increases feelings of tranquillity and lowers heart rate and blood pressure, as water is fundamental to survival.

Biophilia is the theory, and biophilic design is a means to reinforce our connection to nature by recognising that we are biological beings.

Biomimicry is the conscious emulation of functional strategies found in nature to solve human functional design challenges.

The philosophy of biomimicry encompasses the essential elements of ethos, emulation and (re)connection; however, it is usually the emulation aspect that receives the most attention, as it is the most tangible aspect of this philosophy. The (re)connection element is a mindset and practice that seeks to remind us that we are nature and that our existence is intertwined, interconnected and interdependent with her.

From this perspective, biomimicry encompasses the concept of biophilia and promotes the implementation of biophilic design.

**Angus:** In terms of buildings, biophilic design generally refers to either a physical or visual connection between building occupants and the natural world, most commonly with indoor planting or interior spaces that have a powerful

external visual connection to landscape or sky. Biomimicry, however, is a broad multi-disciplinary field that studies and mimics nature's forms, processes and systems to inspire sustainable design. Biomimicry is not simply mimicking the appearance of nature's designs, it is about studying and learning about how nature's designs work, to inspire built-form designs that function better and which contribute to the creation of a truly sustainable civilisation.

**Eco:** What does successful biophilic design look like? And how does it (re)connect us with nature beyond green walls and indoor planting?

**Toner:** It's not a matter of what it looks like so much as how it feels, smells, sounds and even tastes. While green walls, indoor plants and landscaping make a contribution, successful biophilic design promotes multi-sensory engagement with nature and a sense of dynamism that is attuned to place.

Think of how we used to design zoos and how that has evolved. We've come to realise that animals are happier and healthier if they're in an environment that closely resembles their habitat.

By recognising that we are also animals – not in a pejorative sense – we should be designing human habitats that contribute to our health and wellbeing.

Successful biophilic design connects us to nature, and ourselves, by engaging all senses through strategies that: emulate the dynamism and rich experience of natural systems; integrate natural materials and reference natural forms and patterns; and incorporate spatial configurations that address psychological needs such as refuge, mystery, prospect and even peril.

**Angus:** Successful biophilic design creates a powerful connection between the building interior and the exterior natural world – connecting the occupants to not only landscaping, but also to the sky, sun, wind, earth and all the dynamic variations of the natural world.



## EMULATING CROCODILIANS FOR HVAC

As a biomimic, Toner likes to think about saltwater crocodiles as a potential mentor for HVAC design strategies.

“They’ve been around for 400 million years so obviously have powerful survival strategies – among which is their ability to maintain an optimal core body temperature of between 30 and 32°C through physical, behavioural and physiological mechanisms,” Toner says.

She says the oblong, bumpy scales of crocodiles provide some degree of self-shading and, by basking in the sun and adjusting body posture they expose different degrees of surface area to the sun. High external temperatures trigger an increased rate of blood flow from the body’s core to the peripheries, regulated by a series of valves that open

or close to direct heat flows, promoting or preventing heat exchange.

“To avoid overheating, salties return to the water or lie with jaws agape allowing cool air to circulate over the highly vascularised skin in their mouths, which causes evaporation and, through countercurrent heat exchange, localised cooling in the region of their brain. This clever strategy allows them to maintain their sensitive nervous system at a different temperature from the rest of the body.

“Abstracting this, I imagine a building (not in the form of a crocodile) that has adjustable shading elements, variable heat flows to peripheral elements and evaporative cooling to maintain optimal temperatures for areas that require more controlled temperatures.

which relies totally on air conditioning. Our HVAC systems need to be minimised and work in mixed mode, and in tandem with a high-performance passive envelope.

The growing interest and uptake in the Passivhaus standard exemplifies this.

**Eco:** How far away is the use of HVAC to mimic the natural environment – different temperature zones, breezes, etc., – in the built environment? Are there any examples of this being done?

**Angus:** Not that I’m aware of, and I’m not sure if we should be trying to mimic the natural environment with HVAC.

Why not let the natural environment connect and activate with the buildings interiors through great passive design, with the HVAC system operating only as required?

**Hes:** I am not sure I can answer from an HVAC perspective. But the link to smart sensors and their ability to actively engage the conditioning systems is a great opportunity for this.

**Toner:** Mixed-mode ventilation is already being utilised in sustainable building design, so I don’t think it is far away at all. It’s a matter of redefining the parameters for the indoor environment by weighing human health and wellbeing above the certainty of specific thermal conditions.

Before we had the mechanical means to maintain thermal comfort, ventilation and humidity, we utilised passive design strategies that harnessed freely available energy flows. By emphasising passive strategies appropriate to place, then adding mechanical systems to meet the shortfalls, both sustainability goals and biophilic needs can be addressed.

**Eco:** Does this throw out any notion of the “correct” temperature for building occupants (ASHRAE Standard 55 for example) because there really isn’t one – rather different temperatures in different spaces at different times?

**Toner:** Absolutely!

**Hes:** This is partly about control and partly about responsiveness. Research shows that having the ability to adjust temperature and airflow to your needs helps productivity and wellbeing. This means the occupant gets to choose the right temperature.

There is also a strong overlap between passive design and biophilic design in this sense. Both look to create beautiful comfortable spaces to occupy and delight in, for our own wellbeing, as well as reducing our energy consumption and reliance on air conditioning.

**Hes:** A biophilic building integrates the experience of nature; green walls and indoor plants are a part of that. But it is also providing more natural temperatures in the building, providing non-uniform temperatures across a floor plate and allowing people to drive their own fresh air and temperature systems. It also provides views out to nature, connection to natural sounds and smells and the use of natural shapes.

**Eco:** It would seem HVAC has an important role to play in this regard?

**Hes:** The days of a standard temperature across a floorplate with 80–90 per cent recycled air are over, and the HVAC industry can drive what this looks like. Tools such as WELL actually define outcomes such as these – and are driving many of the design decisions for commercial buildings.

WELL specifically looks at the ability to access nature within and outside

the building, incorporation of natural elements, light and space design. WELL also specifies that: “All spaces in naturally conditioned projects meet . . . ASHRAE Standard 55-2013 Section 5.4, Adaptive Comfort Model.”

**Toner:** The most obvious role for HVAC in biophilic design is to allow for building occupants to have a variable experience of thermal and airflow conditions that mimic natural environments. This implies a stretched thermal comfort band that could be achieved through a combination of active and passive strategies while allowing for individual control. It may also be that there are a variety of spaces with differing thermal conditions that occupants can choose to inhabit.

While these factors have been understood to contribute to reduced energy use, greater coordination between the design team may be required to account for biophilic elements like water features, green walls and surfaces with different thermal properties.

**Angus:** Architects really have to get the passive design right first, and then the HVAC systems need to be designed carefully into the application. We need to avoid the typical internalised enclosed box,

## BIOPHILIC ENVIRONMENTS REDUCE BLOOD PRESSURE

According to researchers from Harvard University in the United States of America, indoor biophilic environments can be directly associated with a decrease in blood pressure.

In their paper “Physiological and cognitive performance of exposure to biophilic indoor environment” published in a recent volume of the *Building and Environment* journal, researchers examined the physiological and cognitive responses of 28 participants who spent time in two indoor environments – one with biophilic design elements and one without.

Wearable sensors were used to measure blood pressure, galvanic skin response and heart rate, while cognitive tests were administered after each exposure.

The research found that the indoor biophilic environment was associated with a decrease in participants’ blood pressure.

“The overall differential effects for participants experiencing an indoor environment with biophilic elements versus none was 8.6 mmHg lower systolic and 3.6 mmHg lower diastolic blood pressure,” the paper says.

In addition, the participants’ skin conductance decreased 0.18  $\mu$ S greater than when they experienced the non-biophilic setting.

Short-term memory also improved by 14 per cent.

“Participants reported a decrease in negative emotions and an increase in positive emotions after experiencing the biophilic setting.”

Additionally, the research found participants gained a similar benefit from exposure to a virtual biophilic environment as when experiencing an actual environment.

**Angus:** We definitely need to be more flexible and adaptable! Trying to maintain an indoor environment that essentially never changes is not only excessively energy-intensive – it is also psychologically unhealthy, as we become disconnected from other people, the natural world and biophilic connections that our human bodies need.

This internalised indoor environment has led to excessive “screen time”, less socialisation and the advent of the new phenomena of “nature deficit disorder”. We need spaces that are openable and responsive to the natural world and other people!

**Eco:** In that sense, does the HVAC industry need to move from delivering an imperceptible service to a noticeable one (ironic given the HVAC industry has tried to not be noticed by occupants/tenants)?

**Angus:** Possibly. For mixed-mode buildings, it would be great to have a realisation of when the building is operating in natural ventilation mode versus mechanical mode. This would help emphasise a biophilic connection with the external world.

**Hes:** In nature you notice a breeze. If you are hot or cold, you adjust things. That is what is healthiest from a biophilic perspective – being an active participant in your environment.

It is a major shift in thinking though. You are right that in the past not noticing is a sign of success, but it is not the healthiest and does not provide the most productive and effective workforce.

**Toner:** Indoor environments that deliver subtle sensory variation of thermal and airflow conditions, and more diverse experiences of thermal comfort, could be considered as imperceptible as those that conform to those designed to meet the needs of a man in a suit and tie.

**Eco:** What is the economic case for biophilic design in the built environment, and how willing are building owners to embrace it?

**Angus:** The bar is really being raised in the commercial sector, with the retention of talent being the primary competitive driver.

Biophilic design is definitely playing a part in this, as the creation of higher quality interior spaces becomes expected by employees.

**Toner:** *The Economics of Biophilia* by Terrapin Bright Green is an excellent resource for supporting the business case for biophilic design. It brings together the findings of a range of scientific research papers, and highlights the potential for improved performance over a range of indicators, which include the benefits of daylighting for increased learning and concentration; how a view to nature reduces time spent in hospital; and reduced crime statistics where nature is well integrated into urban design.

Big-name corporations like Google and Amazon are pursuing biophilic design in their office fitouts to improve the health, wellbeing and overall productivity of their people. The benefits of biophilia have been recognised in the design of new hospitals like the Royal Melbourne Children's Hospital, which features an aquarium and meerkat enclosure, and Lady Cilento Hospital, which integrates a series of sensory gardens. A flood of articles espousing the benefits of biophilic design is increasing public awareness. All of this is contributing to a greater demand and increasing the willingness of building owners to embrace biophilic design to improve the value of their assets.

**Hes:** Biophilic design has many aspects that show the benefit both physical and mental. Terrapin Bright Green's "14 Patterns of Biophilic Design" is a good summary of research. There is also the whole biophilic city movement, which brings biophilia out from the building to the whole precinct.

#### **Eco:** How does biophilic design align with the WELL standard and the Living Building Challenge?

**Toner:** The Living Building Challenge promotes regenerative design, a paradigm shift where human systems are aligned with the natural world through the design of the built environment. Biophilic design is an intrinsic part of that transformation, enabling us to rediscover our true nature as citizens and custodians of Earth.

The WELL Standard seeks to advance the design of indoor environments that contribute to human health and wellbeing, and in that regard biophilic design is a fundamental component.

**Angus:** The excellent Living Building Challenge incorporates a specific "petal" called Health and Happiness, which includes a specific biophilic environment imperative that looks

‘ Biomimicry is learning from nature, while biophilia is our need to be connected to nature ’

to create strong relationships with place in terms of climate, ecology and culture. The WELL standard talks about biophilic connections through nature incorporation, pattern incorporation and nature interaction.

**Hes:** Having a biophilic design workshop is integral to the achievement of a Living Building Challenge certified building.

Within this workshop, the design team work with the engineering team workshop on how they will integrate nature into the building project. For HVAC engineers, this would centre on the implications of natural ventilation, daylight, views, temperature design, air movement, and individual control.

#### **Eco:** What can we expect to see in another five years?

**Angus:** Hopefully a greater understanding and appreciation of sustainable design – in that it is not just about doing the right thing by the planet, but also about creating healthier, beautiful spaces to occupy that cost less money to operate.

There is already a greater appreciation of how interior environments impact upon people and their productivity, with the acknowledgment that happy, healthy people bring many economic, commercial and cultural benefits to organisations. The rising cost of energy has also become a major issue, which is assisting the uptake of sustainable design initiatives.

**Hes:** I think WELL will be integrated into all quality building developments. It will start to push the regulators too, as its economic implications start being demonstrated in savings to the economy. Biophilic design specifically

will start to be linked more strongly to less absenteeism and less illness – people are more resilient when connected to nature mentally and physically. This will especially be so if the increase in absenteeism in non-biophilic buildings becomes more evident.

**Toner:** The first step is raising awareness about the benefits of biophilic design so that demand for it increases. At the same time, we need to educate the building industry about the patterns of biophilia and processes for integrating them into design. And of course we need more examples to demonstrate how joyous life can be when we're connected to nature.

As people come to see their existence being intertwined and interdependent with the life around them, the potential to more deeply understand why we urgently need to act on climate change increases.

Integrating biophilic elements into our buildings and cities has multiple other benefits like increasing habitat and biodiversity, providing shade, sequestering carbon and reducing the urban heat island effect.

The delightful thing is that all of these attributes contribute further to our health and wellbeing by mitigating the impacts of climate change. So I imagine our cities being greener and replete with water features and the sounds and smells of life, both human and non-human.

Biophilia can literally be interpreted as the love of life, so biophilic design puts the heart back into "why" we need to go beyond the non-inspiring checklists of "what" we do to be sustainable.

My hope is that biophilic design shifts the paradigm to a regenerative future as we realise our intrinsic relationship with nature and co-create buildings and cities with nature to contribute not just to human wellbeing but also to the wellbeing of the planet. ■