Bio - Inspired Research Centre

Master Thesis explanatory document
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The building envelope is undergoing change. We still expect it to provide thermal, light and visual comfort for its occupants, but not at a huge energy and climate cost for the natural environment. Designers should look more towards nature for inspiration than towards industry when seeking solutions. The question for this project is: How can lessons from natural systems be utilized to create an architecture that includes and functions like living nature? Sustainable buildings save energy and generate energy, mostly by having or relying on a super efficient envelope. This project will focus on the design of a building skin and other bio-inspired strategies that are sustainable, energy efficient, aesthetically pleasing and incorporate elements of living nature. The brief chosen is to design an environmental and technologies research centre in a harbourside setting in Auckland using the bio-inspired formula of biophilia, biomimicry and bioclimatic principles. The imaginary client is a consortium of University of Auckland, AUT and UNITEC universities. The site is a vacant section near the Silo Park at the Wynyard Quarter (former Tank Farm) on the Auckland waterfront. The outcome of this design process is a 4 level building of approximately 10,000 sq metres, with an atrium and interior courtyard in the middle. The main feature of the building is a sophisticated façade system that envelopes the building entirely. This double skin facade employs biomimicry, biophilic, and bio-climatic principles in a manner that more than halves energy and water consumption compared to a conventional building of this size and purpose. It also achieves superior working conditions for its creative occupants, enhancing both their well-being and productivity.
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introduction
Introduction
1.1 Aims & Purpose

The location of this project is in Wynyard Quarter, a harbourside community close to the CBD. At present it is an area undergoing major revitalization and redevelopment and has just been designated as one of the key hubs of innovation in Auckland’s future economy.

This project aims to explore opportunities to design a building for technological research by emulating natural systems with a special focus on building skins. In recent years evidence has been published in many developed countries regarding buildings and the vast amount of energy and materials used in creating and maintaining their existence. This not only depletes valuable resources, but is largely responsible for the climate change experienced in recent years. The number of people living in cities has now exceeded the rural population. As a consequence, larger and denser cities result in less green spaces and an increase in hard surfaces. This exacerbates global warming and demands further energy for cooling. The Garnaut Climate Change Review commissioned by the Australian Government in 2007 warned that ‘On a balance of probabilities, the failure of our generation on climate change mitigation would lead to consequences that would haunt humanity until the end of time’. This means reducing our energy needs and relying entirely on clean, renewable, energy is a matter of survival. This project would both accommodate an organization that seeks clean energy solutions, and be an example of a building that is a solution itself.

1.2 Background Information

There have been a number of key proponents who have sought out alternate solutions when solving design problems: Janine Benyus; Stephen Kellert; Judith Heerwagen; Amjad Almusaed and Timothy Beatley. They have generated an interest among many architects and designers to use designs inspired from nature.

In this paper I will illustrate with examples of biophilic, biomimetic, bioclimatic models that have been successful with regard to using natural systems as design tools. This will link to the precedents that have influenced my design process. From this point I will examine the design features of vernacular building skins that optimize the energy performance of buildings. Following this I will address my completed project and make connections that have been inspired by biophilic, biomimetic and bioclimatic design principles. This will make links with my research questions. This type of approach to design ideally requires the combination of both creative and technical input, that has elements of both design and engineering.
1.3 Brief Development

My brief was to design a building to accommodate a centre for research and development in sustainable solutions. The four fields of research involve information technology (IT), building technology (BT), environmental technology (ET) and transport technology (TT). While each of the four research teams will be located in different areas of the building their work and projects will necessitate for working collaboratively to solve design problems.

The facilities they will require include areas for research, lecture theatres, a conference area, offices, workshops and laboratories. The building will also include: retail, a fitness centre, café/restaurant and public spaces on the ground floor. Car parking will also be available in the basement area and on the roadside outside the building.

A key project objective is to incorporate design features that include biophilic, biomimetic and bioclimatic principles into the design and explore the expressive potential for such systems.

The main focus for this project is the design of the building skin. But I will also comment on internal comfort, and the generation and conservation of energy as these areas are integrated into the building’s structure and function.

The building has to fit into the standards set by the Auckland City Master Plan. As a key area of revitalization, the Wynyard Quarter promises to be a special area for the people of Auckland to enjoy, but also accommodate an ‘innovation precinct’ and technology based businesses. The vision is to create a mix of residential, retail and commercial development while retaining the successful boating and fishing industries.

It was important to take into consideration aspects of building height and form. The Auckland City Council proposed an appropriate scale in relation to the waterfront and the proposed street and public space networks. By having height restrictions, the sight lines of buildings between the Wynyard Quarter and the adjacent areas would be uninterrupted and make the most of the harbour views. The Council also restricts the Floor Area Ratio (FAR). This requirement encourages more variety of building form and use, injecting more diversity and character into this special area on Auckland’s waterfront.

1.4 Research Questions and Objectives

To achieve the objectives of designing a sustainable building skin using lessons from natural systems, two questions have been proposed.

1. How can lessons from natural systems be utilized to create a building that incorporates and functions like nature?

2. What are the design strategies to accomplish efficiency and sufficiency, as well as structural stability, human comfort, economic activity and aesthetic effect?

In order to investigate these questions, this project will attempt to achieve the following objectives:

- successfully integrate living nature into the building
- show that the presence and integration of living nature in the building results in increased resource efficiency
- show that the proposed design is a truly biophilic environment and is one that creates and enhances well-being, creativity and attractiveness.
2.0 methodology
2.0 Methodology

This project focuses on the design of a large-scale building to accommodate some of the best talent in New Zealand, gathered to create technological solutions to the problem of environmental sustainability. To begin my project, I examined the areas of biophilic, biomimetic and bioclimatic by researching literature and articles. It was also vital to have an understanding of appropriate background material on biology, particularly plant physiology, and plant communities. I also explored a wide range of ideas including sophisticated software programmes that produced complex computer algorithms of natural systems as methods of design. Following this, I investigated the area of building skins, identifying the reasons to adopt design strategies that address present environmental problems.

I also examined some vernacular examples that illustrate how building skins using natural systems are true models for sustainability. Prepared with this information I selected the appropriate principles with which to design. I carried out additional research into what makes stimulating working conditions and reasons why people like the presence of living nature in their surrounds.

To assist me in the process, I investigated the Biomimicry Institute’s Design Spiral Methodology\(^3\) as a guide. While there were six stages in total, the first four stages, particularly assisted me with organizing my ideas. The first step was to identify the challenge with the question: what do you want your design to do? The next phase was to ask the question; what would nature do here? The third phase would seek out natural models. The final step was to abstract these natural functions and forms so they can be translated for our human purposes, in order to solve a design challenge in architecture. While on a recent visit to Sydney, I visited some notable buildings as models of sustainable design and selected some of these as my precedents. Those that were particularly impressive and relevant were the Surry Hills Library and Community Centre; 1 Bligh Street; 30 The Bond; and the Telecom Building. All exhibited sustainable innovations, but the Library and Community Centre’s experimental use of plants to bio-filter pollutants was of particular interest.


Figure 2.1 Biomimicry Institute’s Design Spiral Methodology.
I also examined global precedents of building designs within this field. To develop an understanding of the Wynyard project site I gathered historical material and examined the proposed Waterfront Plans for future development of the area. A familiarity with the site was made through several site visits at different times of the day, and in different weather conditions. Careful consideration was also given to building massing and building uses nearby, (some of which are not yet built) as well as sight lines (both inward and outward) and transport routes.

As a design tool, photography assisted me when looking at the overall layout of the site and its proximity to the immediate surroundings. I have included several photographs to enable the reader to have a visual concept of the location and character of this harbourside area.

Following this, I explored the possibilities of arranging the proposed building on the site. From one building, to clusters or multiple buildings, using different heights and sizes to take advantage of views and solar gain.

All this experimentation of ideas was developed through sketching and computer modeling. The experimental stage took time to connect my ideas with, and assess against the design principles I envisaged.

At this point I constructed models to an appropriate scale. This revealed the need to re-examine the physical size of the site. Although this exercise proved unsuccessful, the process assisted me in being more decisive and reflective with the design challenges I faced.

To communicate my design I used sketches and 3D graphics of the architectural concept. I also explained my process and outcome, in the form of my Explanatory Document. The final method I used to communicate my design was presentations using, narrative PowerPoints and animations.
3.0 precedents
research for design
Precedents
Research for Design

The following examples of buildings connect to my design project as they reflect key bio-inspired principles.

The particular elements that relate to this project include:

- Passive climatic design principles
- Natural day lighting through atriums and glass façade
- Energy efficient technology
- Using the earth’s temperature to control hot and cold air
- Façade treatments that control sunlight
- Light and space – to enhance building occupants comfort and wellbeing
- Inside/outside spaces – the transition of interior spaces connecting with the outside environment
- The use of living architecture in the form of green roofs and walls provide positive environmental effects, creates additional recreational space, visual pleasure and wellbeing for the building occupants
- The building must have a definite sense of presence, inviting the passing public to view and enjoy selected facilities, thereby making connections to the urban community.
Surry Hills Library is located in the heart of Surry Hills, an inner city suburb in Sydney. Designed by Architects Francis-Jones Morehen Thorp.

While in Sydney, I visited this building and experienced the quality of the design in this community facility. The main reason it has had a strong influence on my design project, is that it has emulated natural systems to improve indoor air quality, thus benefiting the wellbeing of the building's inhabitants.

**Bio-inspired design elements that influenced my project were:**

The environmental atrium, which manages the distribution, filtering and the purifying of air that is taken in at the top of the building. The air undergoes a series of processes as it travels around the building. An important feature of this process is the use of plants to organically bio-filter pollutants purifying the air before it is supplied throughout the library and community centre. The transparency and plants also create a positive sensory experience for the occupants within the building.
Surry Hills Library and Community Centre also generates its own energy on site with photovoltaic cells on the roof generating its own power for lighting systems and equipment. It is a responsive building as there are automated devices that change and adjust the internal environment conditions. For example, the devices adjust the ventilation and sunshade louvers throughout the day to control heat load, light and shade.

The roof of the Surry Hills building is a green roof, and is not used in the recreational sense, but the building benefits from this form of roof skin through reducing energy consumption and temperature control. Secondly, it reduces noise through its insulation qualities and finally manages stormwater runoff and reduces the heat island effect.

In conclusion, the key bio-inspired element from this precedent that influenced my design is the use of biomimicry design principles where the building's systems are emulating nature to provide sustainable solutions. This is evident in the bio-filter system, the use of plant physiology, and the power of the sun. The use of the earth's temperature in the form of geothermal bores to heat cold air or cool hot air as needed is another strategy to reduce energy consumption by using the natural temperature of the earth. This design creates an environment that enjoys natural light, is warm in winter and cool in summer, has spaces for gatherings, lively interaction, and a place to be inspired and feel invigorated in. A truly, biophilic environment.
1 Bligh in Sydney was designed by Architectus, in association with Ingenhoven Architects and completed in July 2011. 1 Bligh has been awarded a 6 Star Green Star - Office Design v2. Certified rating, the highest Green Star rating score in Sydney, NSW.

**Bio-inspired elements that influenced my project were:**

**Central Atrium**
The naturally ventilated glass central atrium is the main feature of the building as it soars the full height of the building. It provides a flow of fresh air to offices, and a sense of openness on each level. The transparency of the atrium provides views throughout the building, creating communication, connection and community. Glass elevators and sky bridges in the atrium make travel to and from different levels of the work place an exciting, spatial experience.

**Double skin façade**
1 Bligh is the first high-rise office tower in Australia with a double skin glass façade. The first façade is a single sheet laminated glass, while the second is a double skinned glass curtain wall. The outer glass skin has 2 functions; the first is to assist ventilation by installing fixed horizontal ventilation slots into this outer skin encouraging upward airflow in the cavity to expel unwanted hot air. The second function of the outer skin is to act as a weather shield to protect a sophisticated, automated venetian blind system, which has computer-controlled sunshades. These shades are found in the 600mm cavity between the 2 facades.
Technology
The use of a dynamic façade controller is programmed to track the path of the sun. This system adjusts the angle of the blades of the blind depending on the sun’s orientation on the façade.

Rooftop
The large, roof top terrace on the 28th floor provides indoor, outdoor flow connecting interior spaces with the outside environment. This area is designed so spectacular harbour and urban views can be enjoyed.

Energy generation
1 Bligh has energy efficient technology using an innovative tri-generation system that uses gas and solar energy to create cooling, heating and electricity.

Green wall
1 Bligh has a 40 metre-long “green wall” that curves around the side of the building to the courtyard. It uses recycled water to irrigate the plants. It is the largest “green wall” in Australia. The occupants of the building and public can enjoy the positive environmental and visual effects.

Recycled water
All plantings throughout the building are irrigated with recycled rainwater. Black water recycling is used in the building for the washroom flushing system.

In conclusion, the key bio-inspired elements from this precedent that influenced my design were: the concept of a double skinned façade that naturally ventilated, cooled, shaded and provided glare protection for the building; the extensive use of glass for the penetration of natural light into the building; creating outdoor recreational space with planting to enhance the wellbeing of the building’s occupants; finally, the visual transparencies and accessibility of the public, connects the building with the cultural fabric of the urban context.
Precedent 3
30 The Bond in Sydney is a commercial property designed by Peddle Thorp Architects and completed in 2004 and holds a 5 star Australian Building Greenhouse rating.

Bio-inspired design elements that influenced my project were:

Natural features
On entering the atrium of the building you are greeted by an exposed natural sandstone wall that was originally cut by convicts early in Sydney’s history. This wall forms one side of the atrium and insulates and cools the area. The use of this feature brings a connection with nature into the building’s immediate environment. On closer examination of the wall there are plantings of shrubs as well as evidence of water flow. The base of the atrium is a public space encouraging interaction between the building’s occupants and the local community as there are café and lounge areas that make up the social heart of the building. There is also a high level of visibility and connectivity with glazed, office pods projecting into the atrium creating communal spaces for people to gather. This is an environmentally responsive building as there are automatically controlled thermal shades on the façade that prevent overheating and glare in the summer period. In winter the sun is captured to warm the building and the thermal shades respond accordingly.

Figure 3.7 Internal view of atrium, cafe and natural wall.
There is also a roof garden with native plants and timber decking from sustainable sources. This roof top garden provides 3 significant benefits: improved aspect and view from adjoining buildings; a great amenity for occupants of the building, and finally makes a greater contribution to the enhanced biodiversity of the area.

In conclusion, the key bio-inspired elements from this precedent that influenced my design are: a naturally ventilated glass atrium which provides natural lighting and a flow of fresh air to offices; the outlook on to the natural sandstone wall and westerly views to the harbour; the accessibility of the public into the social space allowing interaction with the urban community; the automatically thermal controlled louvers and finally the installation of a green roof with its special benefits.

Figure 3.8 Roof garden planted with sedums.
Precedent 4
Telecom Building

The Telecom building designed by Architectus and Warren Mahoney is located in Auckland, and consists of four office buildings that house 2500 Telecom employees.

Important features of this building are the central atrium that provides natural light and an indoor, outdoor connection. This building is connected by walkways with a common courtyard in the middle. This creates an active and social environment, which encourages greater staff interaction, a “campus like” atmosphere in a social hub.

Cladding material used within the atrium is mostly timber, which creates a natural ambience. Flues are designed to help reduce noise and this allows lounge spaces to be open and assists in creating a feeling of community. The office spaces are transparent, generating a sense of openness and connection. Louvers have been applied as a treatment on the external façade to protect the internal environment.

In conclusion, the key bio-inspired elements from this precedent that inspired my design was the common courtyard with all access ways from the 4 buildings leading to it. This served as an important communal hub of the building in bringing occupants together. The other element was the internal transparency and use of sky bridges for accessibility.

Figure 3.9 Multiple exterior views of the telecom building.
Figure 3.10 Telecom building atrium and sky bridges.
3.1 Summary of Precedents

From the above precedent studies several design strategies have emerged as potentially successful in the implementing natural systems into buildings. Firstly, the design of the building skin that responds physically to the outside environment similar to a natural skin. Accompany this with the use of sunlight for energy and natural lighting; and the design of the atrium and courtyard spaces that provide centrality and transparency to the building; as well as a hub for activity and communication. The visual evidence of the internal environments of these precedents demonstrates liveliness, comfort, and a definite sense of wellbeing. The green walls and roofs not only provide an attractive, relaxing atmosphere for the building occupants and visitors, but also contributes to cleansing and cooling the surrounding air through the process of evaportranspiration.

The integral union of these features between nature and architecture provide us with a connection as building-users to bio-inspired design. These are good starting points from which to move forward.

Other global precedents that I considered were:

- Fallingwater: Architect Frank Lloyd Wright.
- University of Guelph, Humber Building: Ontaria, Canada.
- Ecosistem, Urbano Arquitectos.
- Council House CH2, Architects Disignic, Melbourne Australia.
Figure 3.11 Collage of precedents.
4.0 site analysis
4.1 History

The site is located in Wynyard Quarter, now a popular area for Aucklanders because of its revitalization and proximity on Auckland’s waterfront. It was once one of Auckland’s earliest wharves with construction dating back to 1845. A large part of the area is reclaimed land as there was a need for expansion of port related activities, and this was completed in 1930. After this date the area was used for storage of petro-chemical products and the area was known as the Tank Farm.

As time has passed with the expiration of leases held by petro-chemical companies and changes to bulk liquid transportation, the area is becoming a precinct in search of a new purpose. It has attracted major events and new facilities: the America’s Cup; redevelopment of the Viaduct; the new Viaduct Event Centre; the Rugby World Cup; the development of restaurants; residential accommodation; green spaces and entertainment have all impacted on this reclaimed area.

Despite all the changes the fishing industry still retains its presence in this area with small fishing boats moored to wharves nearby. This aspect adds a definite character and ambience to this marine community.

It is also important to remember that this area is an integral part of the industrial heritage of Auckland and has special historical significance. While it has been decided in future planning to remove most of the petro-tank storage units some will remain to preserve this industrial heritage element and will retain the name, Silo Park. Other elements of marine archaeology including seawalls, slipways and piers will also be retained to preserve the character and identity of the area.

Figure 4.1 Wynyard Pier in the late 1800’s.
Figure 4.2 View of tank farm.
There is a proposed long-term vision termed the Auckland Waterfront Vision 2040 that will give spatial and physical definition to this area. The 18.5 hectares of industrial, reclaimed land is going to be developed into an invigorated ‘mixed-use’ urban area where the population will be able to participate, enjoy and experience the lifestyle of a ‘livable city’.

This vision is already being enacted with a focus on creating a hub of design and creative industries of innovation in close proximity of the CBD. The first is the Innovation Precinct in Wynyard Quarter, a centre to enable entrepreneurs, businesses and investors to tap into the creative knowledge of New Zealand. Another development is the University of Auckland, offering a first postgraduate degree in yacht engineering, by establishing a centre for research and study in this waterfront area.

The whole revitalization planning for this area acknowledges the importance of regaining a link to the water from the CBD, while working towards reinvigorating this urban centre. By creating many diverse areas for work and leisure activities, city dwellers will be able to use and enjoy this unique area.

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Figure 4.4 View of present developments.

Figure 4.5 View of proposed future development.
4.2 Location of site

This project is located on the corner of Beaumont and Jellicoe Streets in the Wynyard Quarter. It is a large, flat site with water access. The openness of the site means that there is the prospect of achieving good solar gain. The main prevailing winds are south-westerlies and north-easterlies, and being in close proximity to the water, sea breezes are common.

The western side of the site enjoys expansive Westhaven water views with access to the water. The northern views look towards the Tank Farm and the proposed park area. The easterly aspect faces the CBD, and finally the southern side looks towards the area of Freeman’s Bay.
The site is easily accessed from the CBD through a network of east west streets, as well as walkways along the Wynyard Quarter over the Te Whero bridge to the Viaduct and CBD. Most people arrive here by car, public transport, cycle or simply walk. As this area is easily accessible, has an interesting proposed re-development plan in place, particularly for establishing centres of innovation, it will make an ideal location for the proposed research, environmental technologies centre. The photographs above explore the sites different attractions activities and features.
4.3 Future Site Developments

Current View of Wynyard Quarter’s Dadly Street and the proposed future development.
The development scheme is aimed to have a ratio of 70:30 for foot traffic and vehicle traffic\(^5\). The proposed green corridors in the accompanying images will enhance pedestrian access. This is a great advantage for the research centre as students and staff can easily access the building. One of the key drivers of this scheme is the 'Park Axis'\(^6\) which is where most of the people movement will occur in terms of funneling users into the social zones of Wynyard Quarter. This is a positive aspect of the proposed research centre. It provides the area with a dynamic urban atmosphere and enables the community to recognise the significance of the building and the research work carried out.


\(^6\) Ibid.
5.0 design principles
The main intention of my research is to examine a model for a suitable building skin design that draws inspiration from nature. We are entering an ecological age whereby when designing a building we are concerned with locations and orientation as well as making informed choices regarding materiality. Studying lessons from nature and exploring the possibilities of how organisms use different strategies and mechanisms will provide some critical thinking into finding solutions for architectural challenges. In the future, using strategies from the rich diversity of nature, and transforming these into technical solutions, for example, building skins will require a specialized collaborative approach from a team of experts in order to arrive at viable solutions. The objective is to learn from nature, it does not mean we are copying nature but it can provide ideas for new design solutions that can improve the current ones.

Benyus warns that while throwing a few technologies into a project is a good start it does not solve the sustainability issue. Only when we consider how everything works together like an ecosystem and is interconnected and operates like nature’s communities can we begin to make a difference. Therefore while we are exploring the use of mimicking natural forms we must transcend this and attempt to understand the principles that are involved within these systems.

Once this has been achieved, we can celebrate that buildings will be more resource efficient, and less demanding on the environment. On the other hand it is interesting to note Michael Pawley while an advocate of biomimicry admits that there are indeed limitations to applying these design principles. Just as with any discipline, it will not automatically produce good architecture, and we should be wary about becoming too scientific about design. He believes architecture should always have an emotional dimension- it should touch the spirit and celebrate the age in which it was created.

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One of the approaches I wish to consider in my project is that of biophilic design. The notion of biophilic design derives from the concept of biophilia, the idea that humans possess a biological inclination to affiliate with natural systems and processes, instrumental in their health and productivity. This idea was first proposed by the eminent biologist E.O. Wilson. He states biophilia “to explore and affiliate with life is a deep and complicated process in mental development. To an extent still undervalued …., our existence depends on this propensity”.

Kellert acknowledges the fact that this human inclination to attach value to nature is somewhat difficult to measure as the data is diverse, but he agrees there is a growing body of knowledge that contact with nature improves human health and productivity. Most of us would confess that we would rather work in a naturally ventilated environment with views, natural daylight, greenery, and a space that promotes a feeling of connection, security and a sense of curiosity. This inclination is true although there is very little reliable data to support his claim. Kellert speaks of green design and sustainable movements that have low environmental impact strategies that minimize and mitigate adverse impacts on the environment. He also strongly supports the “positive environmental impact” or biophilic design approach that fosters beneficial contact between people and nature in modern buildings and landscapes. In addition to this Kellert recognizes the fact that the former approach has been mostly focused on and does commend this, but says it is insufficient, as it ignores the importance of achieving long term sustainability of restoring and enhancing people’s positive relationship to nature in the built environment. This human relationship with nature is basic to human health, productivity and well-being. This is the essence of biophilic design. Ideally the combination of sustainable practices or low impact design and biophilic design results in the practice of restorative environmental design.

10 Wilson, E.O. Biophilia: The Human Bond with Other Species. (Cambridge1984), 35.
12 Ibid.
Kellert provides specifications to assist designers in applying biophilic design in the built environment. He identifies two dimensions and six elements of biophilic design. Briefly, the first dimension deals with the organic or naturalistic subjects. The second dimension of biophilic design has a place based or vernacular dimension, whereby the buildings and landscape connect to a culture and ecology of an area. This refers to the spirit of place, metaphorically transforming inanimate matter into something that feels life like and often sustains life.

As Rene Dubos argues: “The interplay of sensory, emotional and spiritual satisfactions generates the spirit of the place. The environment acquires the attributes of a place through the fusion of the natural and human order.”

The factor of spirit of place is an important one to consider. I believe using principles of biophilic architecture, designers are able to move away from creating buildings that are tightly sealed, air conditioned environments using huge amounts of energy and constantly at odds with the natural environment, to a solution that examines the building’s orientation, form and details to create a comfortable place to live and work. So by using the elements of nature: the sea, wind, sky and sun these elements can be transformed into a biophilic form. It is important to restore the connection between people and the physical environment by connecting to the culture and ecology of a locality. These considerations will assist when seeking solutions to this loss of place problem that created multi-leveled workplaces that are tightly sealed, enclosed and artificially heated and cooled.

14 Ibid; 6.
15 Dubos, R. Wooing the Earth, (New York: Scriber, 1980), 110.
An important biophilic design principle considered for this project is the use of plantings in the form of living walls, roof gardens and green façades. Not only are there important environmental benefits that I will discuss at a later stage, but also this form of biophilic design provides a therapeutic effect for the building’s occupants and offers a human connection with nature. The lush, green foliage provides a sensory and vibrant experience to counteract the physical structure of the building.

Figure 5.1 Living green wall.
Biomimicry and biomimetics are also two other design principles that have influenced my design project. As with Michael Pawley, I intend to treat them synonymously as they have only a slight variation in their definition. He likes to define the discipline as “mimicking the functional basis of biological forms, processes and systems to produce sustainable solutions”\(^\text{16}\). Whereas Janine Benyus defines it as “the conscious emulation of nature’s genius”\(^\text{17}\). This principle has only recently been applied to building design, but it is a recognized fact there is a growing curiosity amongst researchers to investigate the dynamic structures of nature that have evolved over millions of years.

There has been many earlier biomimicry ideas used in other fields. In 1809 George Cayley studied the streamlined form of dolphins and trout in order to develop ship hulls with lower coefficients of drag. More recently the Olympic swimsuits and velcro. Even the Mercedes Biome car was inspired by using the principles learned from bone growth to create a lightweight structure mimicking the shape of a boxfish. Finally paint manufacturers have used the self-cleaning principle of the Lotus leaf to assist in the removal of dirt and grime from building facades.

Figure 5.2 Box and the design of the Mercedes Biome car.

Another example whereby biomimicry is seeking natural solutions to building design is in the area of thermo-regulation. Many animals modify their structures or behaviour in order to make use of free energy, such as wind or from the ground. While these organisms are highly responsive to their surroundings, we are certainly not. This is evident when to maintain the internal comfort in buildings, we use large amounts of energy to pump heating or cooling around.

While biological solutions to thermo-regulation are often complex, multi-functional and highly responsive ours tend to be simple and relatively unresponsive, and the array of necessary functions are generally handled separately by mono-functional elements.

Take the simple example of the caterpillar, by encasing itself into a woven, web-like covering it is able to maintain a comfortable internal temperature within its environment, against the extremes of exterior climatic conditions. This example supports investigation into biological organisms when seeking natural solutions to building design. This area of research is an exciting one and when solutions are found will assist in addressing the environmental problems we are experiencing today. One such biological based design is the use of stoma brick for building skins in arid and dry climates. This was a design, based on principles of several natural systems and abstracted to find a technical solution for building envelopes.

This transformation of strategies available in nature into technical solutions is a complex and complicated interdisciplinary process, particularly when integrating a number of different strategies from different organisms to achieved improved solutions. For example: an envelope that exchanges heat like tuna; regulates heat loss by vasoconstriction/vasodilation as the skin does; stomata openings on a leaf to minimize transpiration; and gular fluttering in the case of birds. While these façade researchers are seeking solutions through a combination of complex biological processes, future research and development into this area promises innovative advancements in high performance exterior skins.

Figure 5.3 Caterpillar incased in a woven web.

In the 1990s a building cited as an example of biomimicry is the Eastgate Centre in Harare in Zimbabwe. The building was designed to regulate its temperature and work like a termite mound. The building would maintain its temperature within a range of a few degrees, despite external fluctuations from 5°C – 30°C using only 10-20 percent energy that a similar block would use for air conditioning. It is interesting to note that the forms of termite mounds vary in different locations, adapting to their environment by adjusting the thicknesses of the walls and heights of the mounds. These mounds are an elaborate system of thermal control with more thickened walls on the sides of the mound that face the hot sun.

The design of the Eastgate Centre was by architect Mick Pearce. He was inspired by the termite mounds that, used a combination of steady ground temperatures and wind induced natural ventilation as a means of thermo-regulation.

“Buildings that adapt to changing conditions is the way we have to develop if we are to mimic truly the low energy ways in which biology works.” With further research and study the prospects of examining elements from nature and using these principles to create energy efficient buildings is an exciting challenge.


Figure 5.4 Views of termite mounds and Eastgate Centre.
In many cases designs in technology that derive from the biomimicry process may not resemble the organism from which the design derived. For instance a solar cell derived from the way leaves photosynthesise may look nothing like a leaf, but it nevertheless works like a leaf and contains a design concept honed over billions of years.\textsuperscript{20} Solar energy using photovoltaic panels is valuable in the sense they not only enable a building to produce its own energy but can supply energy to the national grid.

Another recent development in design principles inspired by nature and comes under the umbrella of biomimicry and biomimetics is the use of sophisticated software programmes. A leading figure in this field is Dennis Dollens, who uses algorithmic modeling of biological systems of branching tree structures, massed leaves, tendrils, roots and flowers for implementing design ideas from nature into buildings. One promising example was using a software programme called Xfrog where the eTree trusses simulated tree trunks and branches. This process models the way in which the growth pattern of trees and plants occur. The branches and coils have spring like qualities that return to their previous state after stretching.\textsuperscript{21} This has valuable implications for buildings that require seismic stabilization. It could also have some time in the future implications for facades that reconfigure themselves as weather conditions change. “Using the tools of technology, science and nature to give buildings and cities biological properties, architecture may be reanimated as an environmental asset rather than a liability”.\textsuperscript{22}


\textsuperscript{22} Ibid; 59.

Figure 5.5 eTree illustrating branches looped and fused into the trunk creating a 3D truss, column or beam.
The design and materials used for building skins affects the interior climate of a building. A sustainable approach to consider is the use of bioclimatic architecture. Amjad Almusaed defines bioclimatic architecture as a building in which a comfortable interior climate can be maintained without active cooling and heating systems. The building heats and cools itself. Passive bioclimatic design principles include orientation of windows relative to the position of the sun, thermal mass, natural ventilation, sunlight and shading areas. While there is the obvious importance of the characteristics of the site, the orientation of the building, its local microclimate, topography and the use of passive design principles there are also other important factors to consider. These focus on the methods for the change of energy levels in a building. Basically heat in a building can be transferred in four ways: conduction, convection, radiation and evaporation.

The first process, conduction is the transfer of heat in a solid, whereby the building’s structure absorbs and stores heat. It is important for architects to measure the thermal conductivity and heat capacity levels of materials used in the construction of the façades and skin so that the reliance on a vast amount of energy to cool the building is avoided and more sustainable solutions are made.

The second process to consider in the energy levels of buildings is convection, which is the process of heat transfer. In the architectural sense this can be achieved in a building largely through natural ventilation. I have demonstrated this in the examples from my precedents and furthermore, in my design project.

The next process to consider for the transfer of energy levels is radiation. This is the process of temperature transfer by means of electromagnetic waves. This has implications for architecture as in order for buildings to be energy efficient and environmentally sustainable the following must be carefully considered: building materials, the massing of the building and buildings nearby, shading, colour and orientation. All are important for excessive heat gain or loss.

24 Ibid; 377.
The final process of controlling internal comfort level of buildings is evaporation, whereby the heating and cooling action works on the principle of heat absorption by moisture evaporation. Evaporative cooling is the natural way of cooling. The air temperature is lowered due to its contact with water when fresh air outside is pulled through moist pads where it is cooled by evaporation and then re-circulated through the building. Therefore heat transfer in buildings is an important consideration when implementing bio climatic designs principles. It is also important when designing a building project to consider climate design parameters. The designer must take into account the latitude of the site. From this point the sun’s path can be tracked so that the solar radiation impact on the building can be calculated.

The form and the axis of the building also has to be considered whether it is cylindrical, square, oval or rectangular in form, whether it has an east, west parallel axis or north south direction. When all these factors are taken into account solar radiation from the sun can be measured where it is direct, ground reflected, or diffused. This will also have an impact on the implementation of bioclimatic passive design strategies; the materiality of the façade, placement of windows, shading strategies, natural ventilation, the internal layout of space and finally the placement of photovoltaic panels.

Another parameter to consider is wind, which is another natural source for passive design. Equipped with data on prevailing wind directions and average wind speeds and velocity of a particular locality during the day and night, the designer is able to use passive design principles drawn from nature when determining systems for ventilation and cooling.

To conclude this section my aim was to inform the reader and provide some understanding into the areas of biophilic, biomimetic and bioclimatic design. This is important, as these are key design principles I am applying to my project in the design of an environmental technologies research centre in the Wynyard Quarter. The outcome from implementing these principles will result in a design that will halve the energy consumption of a building of similar size and provide a vibrant, working environment for its creative users.
The focus for this project is to examine a building emulating natural systems, with a special focus on building skins. To achieve this, one must consider this question: what makes the design of a façade or building skin? Essentially it is the aesthetic covering of a building: exterior walls; roof; and treatment of exterior openings such as doors and windows. It acts as a protective envelope to the body of the building. Beyond the skin metaphor, façades also address a protective element to its occupants providing security and a cultural and symbolic element within the urban landscape.

It is a valuable exercise to study examples of vernacular architecture throughout the world when exploring ways of optimizing the energy performance of buildings, particularly building skins. Vernacular architecture is structures built by people whose design decisions were influenced by the climate, terrain, local materials and culture. Many examples have evolved in response to the challenges of the environment and climatic conditions. The elements of sun, wind, rain, availability of local materials and context will all shape choices made in the design process.

For example in tropical climates the design and shaping of façades is a response to high humidity and temperatures. The porosity of the building skin enhances the ventilation through interior spaces. There are also huge overhangs that shade the buildings from the sun. This design can be seen in the local architecture of countries with tropical climates where the architecture is working with the climate not against. That is, the energy for cooling is using energy from wind circulation rather than from an air conditioner. This is a positive example of sustainability.
The final example I will consider is that of the American Indian. These indigenous people used natural skins as building skins. We may think today how would this considerably thin membrane protect its inhabitants from the elements? The answer is very successfully. The natural skin can regulate temperature and humidity, is often waterproof, yet permeable and integrates everything required in a thin membrane. Furthermore it offers protection from the hot sun, is easily repaired or renewed and is aesthetically pleasing. Plus it is manufactured using local materials and is not harmful to the environment once its life has ended.

Current research is examining present problems with our building skins and addressing the problems of manufacturing, installation and maintenance. When considering these two examples of vernacular architecture, while simplistic in form each can provide important design principles, and that is designing with the elements of nature in mind and interacting with the environment rather than against it. Rather than designing a building which is completely closed and sealed to the exterior environment, this approach provides the architect with design strategies for building skins and the ability to design a system that acts like a filter to the exterior rather than a barrier.
6.0 design process
One of the major goals of the Wynyard Quarter Master Plan is to incorporate a centre for technology industries of innovation. By establishing an Environmental and Technologies Research Centre that explores environmental, information technology, transport, and building technologies, this development will be highly regarded in the Wynyard Quarter. The proposed building, consists mainly of areas for research but also includes retail, delicatessen / lunch bar, restaurant, and a fitness centre. This range of mixed uses will promote a connection of the public and local residents to the activities of the centre. This Technology Research Centre is designed for AUT and UNITEC Universities to promote the development of innovative sustainable solutions.

From my precedent studies several key goals emerged in making the research centre a successful innovative place of discovery.

1. To integrate bio-inspired systems into the building to create a connection with nature.
2. To create a building skin that is energy efficient through using natural systems that are aesthetically pleasing and controls the indoor environment.
3. Provide benefits for building users and visitors from being in a building where you can see and learn about systems from nature.
4. Provide a user-friendly, sustainable design that fosters wellbeing, and opportunities for collaboration and dialogue.
5. Being inclusive to the wider Wynyard Quarter community by providing the public with an interface into the research centre and its amenities.
The proposed building is located on the corner of Beaumont Street and Jelli-coe Street with a new extended Madden Street running along the southern side of the building, enabling access to the new development of Wynyard Quarter.

**I selected this site for three main reasons:**
The proposed building as part of the new innovative technological hub will create an image of creativity to the public within the Wynyard Quarter community. Secondly, the site has easy access and transport to all three universities, as well as being in close proximity to the Auckland CBD. Finally, its location near the water provides the opportunity of integrating nature into the design.

Before I designed my conceptual ideas it was important to have a full understanding of the physicality and context of the site. Factors to consider were the topography of the site, its relationship to climatic conditions and massing of nearby buildings. I recognized the challenge of finding design solutions for the intense, westerly sun and prevailing southwesterly and northeasterly winds. The site at present lacks any natural features in the form of trees and plantings, and is a complete blank canvas, waiting to be transformed and developed.

To gain knowledge of the sun's position in the sky at different times of the year, I examined Auckland’s Sun Path diagram. This assisted me with useful information about the sun’s path and intensity around the site throughout the year and provided a method of identifying areas of shadowing, which will be an important consideration for my design.

The site is located in a prime location that offers views to Westhaven, the Harbour Bridge, Hauraki Gulf, the surrounding urban landscape and the CBD. To maximize the potential of these views I will need to consider the building's height and openings to capture the exceptional views of the neighboring area.

Access to the site can be achieved through public transport, private car, cycling, or walking. There are good access ways from the site to the CBD, and motorways make north and south connections to the outer suburbs. The main access routes to my site will be through Beaumont Street, which is on the eastern side of the building, and Jellicoe Street, which is on the northern side of the building.

Parking is available on Beaumont Street and Jellicoe Streets for visitors, or in the basement of the proposed building for selected staff.

The new development for nearby Dadly Street, is to transform it into a green corridor and this will form the main connection from Victoria Park and the new Wynyard Quarter development. I plan to extend the green corridor from Dadly Street to my building site. This will further enhance the surroundings of the proposed building and will make a connection with my bio-inspired design elements: through creating green, outdoor spaces in a built environment that will be aesthetically pleasing; harmonise with nature; and be an active, enjoyable space for the community.
6.2 The Concept

As part of the design investigation process I used different mediums to explore the best design options, through the use of sketching, 3D computer modeling and physical models and photography. This assisted me with visualizing the form and massing of the proposed building, and enabled me to examine spatial elements, heights, and relationships between indoor and outdoor spaces, and most importantly the actual physical shape of the building's footprint. While experimenting with my initial concepts, I recognized the importance of the silos as representing a part of the heritage architecture of the area and I decided to include this element into my design.

For the proposed technologies research centre I sought a design solution to accommodate the four areas of technology research. To achieve this I experimented with different arrangements of the physical form of the building. It was my initial intention to develop and preserve the concept of the cylindrical shape of the silos as an iconic representation of Wynyard Quarter and integrate this element into the building.

I explored different layouts using the cylindrical form by using:

- joint clusters and changes in heights and sizes
- multiple buildings of different heights and sizes to take advantage of views and solar gain
- stacking, giving each building a stepped facade
- addressing the intersections and road sides situating the building on the boundary of the site
- pushing and pulling the façade
- single building / cutting into the cylinder creating a central hub

Figure 6.4 Initial conceptual ideas of proposed building form.
While examining these different possibilities I arrived at the conclusion that having separate buildings did not suit my brief, as the technologies research centre involved collaboration and interaction between researchers and postgraduate students. Aligning, by hugging the building on two sides of the roadside boundary revealed two key points. The first was placing the building closer to the roadside gave the building a feeling of presence, but at the same time left a great deal of open, unused site space on the western side that was exposed to the hot afternoon sun, and south-westerly prevailing winds. The solution of landscaping the vacant space on the site was a possibility, but there will be ample green spaces available nearby with the new development, and this would be an impractical idea.

Figure 6.5 Current views of Wynyard Quarter.
Figure 6.6 Future image of Wynyard Quarter showing green spaces.
Possibilities

A selection of the wide range of possibilities investigated

Figure 6.7 Multiple conceptual sketches and models.
As a consequence I explored different treatments of the cylindrical form deciding on the idea of cutting a wedge into the cylinder to create a central hub. The idea of a central hub provided centrality to the building where people could gather as the main social point of the building for recreation, interaction and communication. Within the hub the concept of a green, water tower located in the centre of the hub would serve to integrate plantings and water features as key features.

The purpose of this strategy is to promote features that provide biophilic qualities that would connect to the community. Secondly the green water tower would also be beneficial environmentally - cooling and purifying the surrounding air withing the hub. There is also a possibility of oxygenating stored water. Therefore the inclusion of a green water tower within the design of the hub is a convincing option.

While developing this concept I retained the curved cylindrical form that surrounded the hub, as I wanted a central point in the building to bring the researchers from the four technologies together. I persevered with the design having three sides of the building bordering the eastern, northern and southern boundaries on the road-side, while preserving the openness of the hub to the sea views in the west.
Although the building’s shape and form was coming closer to my expectations, I recognised the effects of the exposure to the westerly sun and winds still remained a design problem. As a consequence I explored various design solutions to overcome this, but realized after some experimentation a satisfactory solution was not reached and I would not achieve my desired outcomes. The central space would certainly not be user friendly in extreme weather conditions. In addition the western elevation of the façade was considerable in length and exposed to excessive heat gain, which would have a negative affect on the internal climate of the building. I finally resolved this design problem by enclosing the western elevation of the building and created a protected internal hub. A design solution for the western façade, was possible and I will discuss this at a later stage.

Initially the shape of the building was gently curved along the 4 elevations but I now needed to limit the amount of curved exterior boundary walls to the four corners of the building, as it was not practical for the internal spatial design of the building and the façade technology treatments I wanted to use. Originally the access points to the building were located within a curved area of the façade. However when I resolved the shaping of the exterior walls of the building I made square, recessed entrance bays to serve as access points. In doing so the four prominent, curved corners of the building now became a feature. This created four designated areas for the four types of research technology, but also included areas for collaboration for integrating their design practice.

As this was a bio-inspired project I needed to implement natural systems that I explored in my precedents. These are described at a later point in this research paper.
6.3 The Skin / different attempts

The main objective for this research is to successfully integrate a bio-inspired building skin design into the proposed building that shows the presence and integration of living nature. The basic function of the building skin is to provide a protective envelope to the body of the building, as well as providing its occupants with a secure, comfortable place in which to work. To achieve this I applied passive bio-climatic principles to this design process by examining the orientation of the building and how it might respond to the local climate. It was important to consider each elevation of the façade and how it reacted to the natural elements, and apply some possible skin solution ideas.

The absorption and storage of heat on a building’s surface also had to be taken into account. The thermal conductivity, and heat capacity of the materials I select in the construction of my proposed building façade and skin are vitally important to achieve comfortable thermal conditions. These conditions include: protecting against heat gain in summer and heat loss in winter.

Another factor to consider in building was the elimination of glare from solar penetration while still maintaining the surrounding views. To examine evidence of solar penetration levels at different times of the day and year I referred to the Sun Path diagram of Auckland City.26 The sun’s pathway can be tracked so the solar radiation impact on the building can be calculated and this would have an impact on implementing passive bioclimatic design principles: the placement of shading strategies, light penetration, the internal layout of space and photovoltaic panels. As well as information on the sun’s impact, data on prevailing wind directions and average wind speeds throughout the day in the Wynyard Quarter area was useful information when considering passive bioclimatic design principles drawn from nature when determining systems for assisting ventilation and cooling to the building.27

27 Wind data Auckland City, Http://www.metservice.com/towns-cities/auckland/aucklandcentral?glid=CMz3hcnCO7UCFSKpgodiBOAaQ.
Finally, as the proposed design was to be a distinguished establishment of innovation design in the area of environmental and technology research it was important to present the exterior form and building skin as representing this philosophy to the public and occupants of the building. The outcome of this would be to validate the intentions and importance of the building’s existence in this new hub of innovation in the Wynyard Quarter.

My initial attempt to design a building skin for my proposed building was focused on examining sustainable solutions. My first concept for the building skin was to use a double glazed, double skin cladding which would wrap the building, protecting and insulating against heat gain and heat loss. This would protect the building, but the western and northern elevations faced the extremes of solar penetration.

Figure 6.10 Sketch of louver system.
To address this problem the solution was to explore the use of electronically controlled louvers on the western and northern sides. Using Auckland’s Sun Path, the direct radiation and the angle from the sun could be measured, and this had an impact on the correct placement of the louvers. In this case vertical and horizontal louvers were used. On the western side I proposed electronically controlled vertical louvers to deflect the impact of the sun’s angle and shade the interior of the building. As the sun on the northern side is at a higher angle in summer the northern façade required the installation of horizontal louvers to deflect direct solar penetration into the building’s interior. The combination of both the double skin and louvers provided a protective envelope, but I felt I still wanted to explore other alternatives even though this could be an ideal solution for my proposed building.

I wanted a concept that integrated living nature into my building design, so that the building skin could work with the systems of nature rather than against it. My research continued to seek out a means of using a natural ventilation system to combine with my double skin and louver system.

While on a trip to Sydney, Australia I referred to the 2012 New South Wales Architectural Awards and found two buildings of particular interest to my façade design: 1 Bligh and The Surry Hills Library and Community Centre. I was impressed with the idea of how both buildings used different, high performance, natural ventilation systems. Both presented a case for integrating natural elements to create a sustainable outcome. As a consequence these two precedents had an important influence on my final design.

1 Bligh's building skin comprised of two separate glazing systems separated by a 600mm cavity. The outer most skin provided a weather shield and protection for the computer-controlled sunshades within the cavity. Within the outer skin fixed horizontal ventilation slots encouraged an upward airflow into the cavity between the skins and prevented excessive heat build up. The outcome of this design reduces the energy consumption of the building as the air conditioning is dramatically reduced. The Surry Library and Community Centre was the most inspiring example of integrating natural systems to improve the internal and external environment. The Surry Hills building skin not only protected it from the exterior elements but also provided a structural skeleton that ventilated and purified air in the building. To achieve this air is taken in from the top of the building, then this naturally tempered air from the geothermal heat exchanger then undergoes the bio-filtration treatment on the glazed south side of the building and then enters the occupied zones through floor grilles.
The outcomes of the building’s performance have either matched or bettered the predicted outcomes. Data is collected and monitored on a regular basis by the City of Sydney Council to measure the consumption levels of the building. The graphs below demonstrate this success as it compares the community centre with buildings of an equivalent nature.29 There are other beneficial outcomes for the building users as they are able to see these environmental initiatives in action as they sit in the library and enjoy reading. Definitely biophilic qualities present here.

This proved to be turning point for the design concept for my building skin as I was inspired by the use of plants and the whole bio-filtration process. The skin protected the building as well as providing a system that supplied fresh ventilated air. It was my goal to use a similar design concept for the building skin in my building, but considerations for the physical size of the building and site location had to be addressed. The development for this design follows in the design outcome section of this research paper.


Figure 6.15 Graph to show comparison of energy performance of Surry Hills and similar sized buildings in Sydney.
7.0 the design outcome
7.1 Functional requirements

The functional requirements can be divided into four categories:

**Post Graduate Students Use** - These are for students to use and occupy.
- Atrium
- Critique Spaces
- Retail spaces
- Seminar rooms
- Restaurant / café
- Exhibition spaces
- Hub / Decks
- Lecture theatres
- Access ways
- Research Laboratories
- Workshops
- Classrooms
- Fitness Centre
- Library

**Public Participation / Interaction** – These are for activities that the public can participate in or interact with.
- Fitness Centre
- Exhibition space
- Restaurant / café
- Car park for fitness centre users
- Retail Space
- Hub

**Academic Staff Use** – These are the administration and office spaces.
- Offices for Head of Technology
- Storage space
- Offices for Professors and Lecturers
- Service space
- Parking Spaces for Researchers and staff

**Researchers Use** – These areas are for Researchers to use and occupy.
- Research Laboratories
- Offices
- Workshops
- Parking Spaces for Researchers and staff
- Storage

Figure 7.1 Six pack silos.
Figure 7.1.1 Functional areas of the building.
Accessibility points to building

1. Entrance to research centre and gallery
2. Entrance to underground car park and fitness centre
3. Entrance to retail stores and restaurant
4. Main site access point via Jellicoe Street which connects through to the Viaduct and Britomart
5. Main site access point via newly developed Dadly Street, using the green corridor connected to Victoria Park.

Figure 7.2 Building accessibility.
7.2 Spatial Layout

Ground floor and Entrance
The main entrance on Beaumont St marks the approach to the ground floor. On entry into the building the atrium forms a vertical view of the open sky overhead. The sides marking the different levels of the building located either side of the atrium are transparent. Ahead the reception area is raised to showcase the entry to the building with walkway bridges above connecting across to different floor levels. Behind the reception are glass elevators and stairs to the above levels. Looking through the atrium and hub, views are visible out to Westhaven Marina and the Harbour Bridge. Public art in the form of a sculpture is displayed in the entrance foyer of the atrium.

Situated behind the atrium is the hub, which forms the social heart of the building. The environs of the hub includes a sheltered, landscaped area with plantings and seating which will be designed around the water tower. Thus the tower is an aesthetic focal point and will also be used to purify, oxygenate water, and cool the hub in summer. Vertical green walls are interspersed on the circumference of the hub walls. This area has access to the waterfront restaurant / café and fitness centre.

The retail shops are located on the northern elevation of the ground floor with the waterfront restaurant / café on the northwestern corner to take advantage of the views and the northerly aspect. The fitness centre is located on the southwest side of the building. This is an amenity for the public and building occupants. The west side is shaded by automated vertical louvers that adjust according to the intensity of the sun. The fitness centre members are able to enjoy views to Westhaven Marina and Harbour Bridge.

Figure 7.3 ‘Imagined view’ of green walls within the hub.
A gallery/exhibition area to exhibit innovative, sustainable solutions in the four areas of research is located on the southeastern corner. This will be open to the community and can be a platform for communicating ideas to the public, and in doing so makes the public aware of the importance and purpose of the building, and the role of the building occupants’ innovative and creative research into environmental technologies.

The southern side of the building marks the services’ entry to the building and the entrance to the underground car park.

Figure 7.4 Ground floor plan.
Level 1

The first floor is the learning centre for postgraduate students. It is accessible by stairs, sky bridges and elevators. A library, classrooms, study areas and two lecture theatres are located on this floor. The lecture theatres are double height and the theatre located on the southern corner is larger, in order to accommodate more people if required. The hub can be enjoyed from decks that overlook the landscaped area, the green water tower and vertical green walls that embrace the inner hub. There are informal study lounges for reading and chatting before lectures. All amenities on this floor are easily accessed from the circulation ring that runs around the circumference of the hub. The bridges that cross the atrium also provide access as well as full views of the building’s activities and dynamic forms, adding a sense of liveliness to the journey. The transparent glass lifts also provide visibility and a sense of energy to the occupants of the building. The environmental skin system that wraps around the inner exterior walls of the building will add a sense of movement as the oxygen travels through the plants. This visual feature creates a pleasant environment to work in. There will be four fire exits in total one in each corner of the building to ensure a safe exit for occupants. It is crucial for a large building to observe the New Zealand Safety Regulations. According to the regulations there must be a minimum of 35 metres access to a fire exit from any point in the building.
Level 2
This floor is dedicated to hands on practical research where postgraduate students explore their research using laboratories, workshops, studios, offices for professors/lecturers and some study/lounge areas. There is a large degree of transparency so that there is collaboration and dialogue to generate interest and curiosity. With this area being fluid in nature it is expressive of a shared learning environment. Once again all amenities on this floor are easily accessed from the access way around the circulation ring, and over walkway bridges. Access to other floors can be made via glass lifts and stairs. From this floor the hub and water tower can be enjoyed from decks that overlook the landscaped area and vertical green walls. The environmental skin system that wraps around the inner exterior walls of the building exposing plantings, is in full view of all workspaces and assists with affiliating humans with nature.

Figure 7.6 Level 2 plan.
**Level 3 & 4**

These two levels are dedicated spaces for professors, heads of research and their teams and staff. The researchers divide into their respective areas – Information Technology, Environmental, Building and Transport. The Environmental researchers are located in the northwestern corner as this gives easy access to the roof gardens. The Building researchers are located on the southwestern corner. The Information Technology researchers are located on the southeastern corner as this is the coolest side of the building, for working with computers. The Transport researchers are located in the northeastern corner. The four areas of research are located in separate corners of the building unlike the postgraduate students, as each requires different research tools and laboratories to conduct their research. However the circulation ring and open spatial plan permits overlap and collaboration between the different groups of researchers when required. On these levels there will be workshops, laboratories, conference areas and offices. The northeastern side with views will be a multi-purpose area used as a lounge and function area allowing social exchange between all researchers from the four areas. Circulation is the same as levels 1 & 2 with stairs, sky bridges and elevators. Open office plan enables visual interaction with the environmental skin that surrounds the building and views to the central hub and water tower. This level also takes advantage of the city and harbour views.

![Figure 7.7 level 3 - 4 plan.](image-url)
Rooftop of the building
The whole roof surface area of the building will consist of a green roof with specialized plants that the researchers have investigated to benefit the building. This will be under the care and management of researchers who are working on green roof solutions. This area will not be open to the building's occupants. However on the northwestern corner there will be a designated, rooftop garden that the building occupants can enjoy for social functions. Access to the rooftop will be by stairs and elevator.

Basement level
The entrance to the basement will be from the south side of the building on Madden Street. This will be the entrance to the underground car park for lecturers, researchers and fitness centre users. There are lifts and stairs that provide access to all levels of the building. Water storage is kept in the basement level, which will be used throughout the building for irrigation and toilets. Other services are also located here. Rubbish recycling and waste systems are also located in the basement.

Figure 7.8 Roof top plan.
Solar Dome, Hub and Water Tower

A permanent, raised cover over the hub will assist in controlling the internal environment. This ETFE cover will protect in winter and shelter against southwesterly prevailing winds throughout the year. The transparency of the ETFE cover will shelter from glare, but allow for light penetration so that the interior of the hub is bathed in dappled light throughout the day. The purpose of this area is to provide an area for social interaction, meetings, social functions or a quiet retreat for lunch. While in the hub building occupants are able listen to the sounds of trickling water from the green water tower, and enjoy the plantings from the vertical gardens and landscaped area within the hub's space.

The hub interacts with the building's occupants through the glass facades at different levels of the building. This provides a sense of openness and connects the community of the building. Located on the north-east and west sides of the dome are laminated photovoltaic panels to provide energy for the building. The dome is an ideal shape for these photovoltaic panels as the rounded shape absorbs the sun's energy evenly as it moves across the sky throughout the day. These laminated photovoltaic panels will still allow the penetration of light into the hub.

Figure 7.9 View of hub through ETFE cover and photovoltaics.
7.3 Developed Skin/Façade

The aim for this project was to develop an aesthetically pleasing and energy efficient building skin / façade that would draw on taking inspiration from natural organisms and elements within the environment. I also wanted to create a building that inspired and created an ideal atmosphere for innovative research. To achieve this, I intend to integrate the structure of the building with a natural process that will enable me to reach these outcomes. I have decided to use the process of bio-filtration as the natural process to purify air within the building and integrate this system within the skin and façade of the building. In this process the incoming mixed air passes over plants through the process of photosynthesis, the plant absorbs carbon dioxide and other pollutants and releases oxygen as part of the photosynthesis process. This air is then distributed throughout the building. This process will be integrated with natural elements of the sun, wind, seawater and the earth to achieve a building skin that incorporates and functions like nature.

For the readers' reference I have called the system for my proposed building the “environmental skin system”. My research centre is on an open site with fewer constraints, so the opportunity to apply this environmental skin system on all sides of the building is possible and this is what I have decided to do. The façade for the research building consists of two glazing systems. The first is a single glazed exterior skin of 26mm laminated heat strengthened glass and an interior double glazed skin of 26mm laminated and toughened glazing, the interior layer is impregnated with mirror reflective polychromic frit. This is the 'unplanted' part of the façade, located in the rectangular bays.

Figure 7.10 Location of rectangular bays.
The second is the environmental skin system, which has a single glazed exterior skin and a single glazed interior skin. Between these two single glazed skins are triangular double-glazed voids where the plants are located and the incoming air and supply air will travel through. The triangular air voids need to be double-glazed as the incoming air is warmer and the supply air will be cooler. The exterior, interior glass façade soars the full height of the building from the first floor to the top of the building. To assist with shading and protection of the plants, louvers will be placed on the northern, eastern and western side of the building.

The ground floor area is recessed with level one cantilevering over the entrances and exterior walls providing shelter to this level of the building. The environmental skin system is a special feature of this building, as the occupants have full surrounding views of the plant life that wraps around the building.

In Surry Hills the construction of the environmental atrium restricts the height of the plants, but with my design I am able to plant at the base and have hanging plants growing from the top level of the building. Trellis wire framing within this cavity will support the growth of some plants. This will provide a dense, luxuriant collection of plants as there are no restrictions regarding height. The selection of plants will be chosen to suit the various environmental conditions on the different elevations of the building.
How it works

Exterior skin
Triangular double-glazed voids

Voids
1. Outside air
2. Supply air

Supply air

Outside air

Outside air intake
Geothermal coils
Interior skin
To geothermal loops
Plants

Labyrinth

Geothermal Heat Exchanger

Figure 7.12 Exploded view of the environmental skin system.
Plant list left to right:
- Sinobambusa tootsic - Bamboo
- Scindapsus aureus - Money Plant
- Sansevieria trifasciata - Mother Inlaws Tongue
- Cissus antarctica - Kangaroo Vine
- Philodendron 'Xanadu' - Dwarf Philodendron
- Sedums x 2 for the roof garden.

Sedums are able to withstand extreme weather conditions and the salty atmosphere of a maritime setting.
It was necessary to design a protective shading system to be positioned in front of the plants to protect them from excessive solar penetration and heat. This will also protect the internal environment of the building. I have selected to use an electronically controlled louver system that has a built-in sensor and moves according to the sun's path and intensity. As mentioned in my conceptual stage it was important to consider the angle of the sun's rays in order to deflect heat. On the eastern and western elevations, vertical louvers were used, as the angle of the louver would deflect the eastern and western sun's rays. On the northern side, horizontal louvers were suitable because the blades deflect the high-angled northern sun. The louvers will be a light coloured, timber veneer and will suit the context of the building. The south side has the environmental skin system but does not require this louver system as the sun's intensity does not warrant it.

Figure 7.14 Eastern elevation showing vertical louvers.
Figure 7.15 Northern elevation showing horizontal louvers.
This southern side is transparent to the street and enables passersby to view the activities and plants within the building. Providing this sense of transparency creates an open, vibrant environment. As I have mentioned previously the rectangular bays on the three elevations do not have the environmental skin system but have a double skinned glass system. The first façade is a single sheet of laminated glass while the internal façade is double-glazed. To prevent overheating in these areas the outer skin will have fixed horizontal ventilation slots that, will encourage upward air flow into the cavity and this will expel the unwanted hot air. Each level of the building within the bay has an overhang shading system that also assists in the prevention of overheating. These areas are not planted because they are directly opposite the circulation ring. This enables researchers to have uninterrupted views of the surrounding area from the glass façades as they move around the building.

Figure 7.16 Section of rectangular bay air flow and shading system.
The next stage is to describe the air-cooling and heating systems for the environmental skin system. Surry Hills used a ground cooling water system all year round. As my site is located on the water’s edge I decided to use a water to water heat pump system for the winter months, as the sea temperature in summer is too high to cool the building. In summer I will use a ground water cooling system, exchanging heat without any refrigeration. Having two systems is an advantage as it is easier to maintain and service, as when one is not functioning it can be maintained and serviced. This means that the building is fully operable all year round and doesn’t need to close for maintenance.

Figure 7.17 View of water supply for winter system.
Winter
In winter a water to water heat pump system is used. The process works in the following way: seawater is extracted from the viaduct at the closest point which then is pumped to the top of the building to the heat exchanger, this is where the air intake is located and will be heated before entering the building. The air intake will be at the highest part of the building aided by prevailing winds when possible. Once the seawater passes through the heat exchanger it is returned to the sea through another pipeline. The tempered air is drawn down the building through the outside air voids which passes through the biofiltration process, whereby the plants and biomass help reduce external pollutants as well as increase oxygen levels. It is then transferred through to the air supply voids by fan units which helps drive the air, then it passes through the biofiltration process for a second time with a further fine grade of air filtration. This purified, high quality, naturally tempered air enters the occupied zones through the floor grilles that are positioned throughout the building. The air is naturally relieved through the building at the top of the air supply voids.

Figure 7.18 Diagram to show winter water to water heat pump system.
Summer

During the summer season the building will be using a ground cooling water system. This system works like a respiratory system, with the air taken in at the top of the building. The intake naturally tempers the air as it flows across geothermal chillers coupled to geothermal bores that draw energy from the earth 100 metres deep to cool hot air. The process of bio-filtration and air supply is the same as in the seawater heat and cooling system. The pumps used in both systems and the fan units used to drive the air will be powered by the photovoltaic panels located on the dome and atrium roof at the main entrance of the building.

The environmental skin system combined with the louvers controls the whole internal climate of the building. However it does not work totally independently as it requires the assistance of the ground cooling water system and the water to water heat pump system to function efficiently. The photovoltaic cells also function as a part of this system as it powers fans and pumps. Therefore the design of this building skin in the proposed environment technologies research centre involves a multifunctional approach that is sustainable and energy efficient using the natural process of bio-filtration and natural elements – the sun, water, earth and wind.

Figure 7.19 Diagram to show summer ground cooling water system.

1. Air Intake
2. Geothermal chillers
3. Filtered tempered fresh air supply
4. Air tempered and filtered through thermal Labrinth
5. Geothermal bores
6. Geothermal chiller supply
7. Controlled air relief
8. Dome photovoltaics
8.0 design outcome
"A building need not look like a tree, but it fauna listed Wright reminded us; it should work like one."
9.0 conclusion
The main theoretical direction of this project is aimed at designing an environmental research centre using a bio-design formula based on biophilic, biomimetic and bioclimatic principles.

The objective was to translate these principles into design strategies to create an innovative building skin that would not only be an aesthetic protective covering that controls the indoor environment, but also creates and fosters wellbeing and creativity. A research centre that has presence, a ‘spirit of place,’ that connects with people.

The external building skin of the research centre delivers a strong, robust appearance from the outside and creates a degree of interest and curiosity to passersby with the contrast of louvers and glass facades and glimpses of vigorous green plantings. As an established place of innovation and research the building sits well within the Wynyard Quarter community and this connection strengthens the culture and ecology of the area.

Within the building the strong visual impact of the environmental façade with the green plants growing in the cavity provides a unique workplace environment. Not only the health benefits from the process of photosynthesis but also creates a direct connection with nature. The implementation of these bio-inspired design strategies has resulted in a research centre that provides not only structural stability but an internal environment that is conducive in creating an inspirational setting for innovative research.

The process of the design of this building skin involved a number of key systems that needed to work collectively: oxygen from photosynthesis, power from the sun, warmth and cooling from the earth and sea, as well as air driven by the wind. The building could be described like a living organism responding to different conditions and resources within its environment.

By modeling this process the design strategies utilized in this research centre has minimized the adverse impact on the environment by integrating systems and elements from nature into the design thus accomplishing efficiency and sufficiency agendas. This involves in conserving and generating 2 key resources – energy and water.

The question remains will the outcomes of the research centre in the Wynyard Quarter be successful? After examining the data from Surry Hills the evidence indicates very favourable outcomes. The building in Sydney is performing well in terms of energy use, as well as positive responses reported from the building’s occupants.

The spatial design of the building responds to the different functions required by the researchers from the fluid nature of the studios used by postgraduate students to the dedicated areas for senior research staff on the top levels. However opportunities for collaborative research work, conversations and sharing of information on sustainable issues are encouraged on all floors. Transitions to different parts of the building can be an exciting journey traveling over skybridges, in the glass lifts and walking the circular ring that overlooks the central hub. The hub is almost like an oasis or green sanctuary in the middle of the building providing an area where people can restore a positive relationship with nature in the built environment.

Conclusion
Self Assessment

I believe the main outcomes for this research building have been achieved. Firstly the building skin is sustainable, energy efficient, aesthetically pleasing and integrates living nature into the design. For this outcome the hard evidence can be measured from the design solution used for the building skin that results in a vast reduction in the use of energy and water consumption compared to a conventional building.

The second outcome focuses on the biophilic design principle that the importance of contact with nature improves health and productivity. The research centre is naturally ventilated, has views, natural daylight, greenery, and a space that promotes a feeling of connection, security and a sense of curiosity. All encourage conditions for creative innovation in this environmental and technology research centre.

The third outcome focused on my precedents and the influences they had on my building. Elements of each of the main precedents I identified as significant connected with my bio-inspired philosophy as well as influencing my design concepts. I was able to be inspired by the new technologies that were both sustainable as well as fitting into my brief for a research technologies centre in the Wynyard Quarter.
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