Evoking Spatial Experience through Biomimicry and Biophilic Design

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of the 180-point Master of Design Degree at
Auckland University of Technology.

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Attestation of Authorship

"I hereby declare that this submission is my work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the qualification of any other degree or diploma of a university or other institution of higher learning, except where due acknowledgement is made in the acknowledgements."

May 2018

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Thank you.

CONTENTS

Abstract

This project in biomimicry and biophilia is a very challenging project for me as a landscape design graduate. I have always loved to design landscapes and interior spaces in which people are able to enjoy themselves. Biomimicry and biophilic design have opened my mind to the idea that spaces created according to nature provide a much more beautiful experience for the occupants. The principle and theory of biomimicry have provided me with new interest and enthusiasm to improve my landscape design skills in ways that I never imagined possible before I conducted my literature search and literature review in both biomimicry and biophilic design. I have come across many fantastic concepts based on nature that I believe creativity alone would not have come up with: the innovation, beauty and sustainability that nature can tell us about.

In this design project, I have combined the theory and principle of biomimicry and biophilia to create an emotional and meaningful experience in various forms and in the shape of pavilions in which people can have meaningful conversations. Also, most importantly, this is a great experience in the visual, spatial, architectural and natural environments. To ensure that I can create this kind of experience for the human factors used, such as the four pleasures, to enable me to design not only a beautiful pavilion

and spaces but also a pavilion that is a psychological, physiological and social experience for people. Some aspects of nature enable me to create a structure that mimics the form, function, and system of natural plants and insects. This is what biomimicry is about. All the concepts and final design of my pavilion have mimicked the organic shapes of nature. Also, I have been influenced by the application of biophilia which lays out a range of tools for understanding design opportunities and is an effective way to enhance the well-being of humans.

The pavilion that I have designed is based on the mushroom, and a piece of leaf; the process has confirmed my thinking about the beauty and significance of biomimicry.

Due to limited time and technical skills, I have made visual prototypes of various pavilions but they are not perfect; they are merely examples of how I can apply my humanity in research, using approaches such as heuristics and trial and error. Based on the mimicking of nature, through biomimicry and biophilic design, I want to introduce a natural structural space that is seldom imaginable by the human brain alone. The project has taught me and prepared me to be a more imaginative, sensitive and sustainable landscape architect, and I will pursue that aspiration in the future.

1. 0
Introduction

1.1 Background

The quality of public space in cities directly impacts the quality of urban life. The open spaces work as a significant factor that can provide the public with experiences of the city in a landscape environment. Also, it influences the mood and health of the population as well. Therefore, I am taking advantage of a view to build a pavilion which is typically thought to be the best idea for catering to people's physical and psychological needs. Often its function makes it an object of pleasure. That is to say, the "pavilion" (Pavilion, 2018) plays the part of landscape architecture that could offer the public a temporary stay in a beautiful landscape. At the same time, the relationship between people and nature could be considered in depth. As a consequence, the pavilion functions as a bond between human beings and the environment.

1.2 Research Question

What are biomimicry and biophilia, and how can the two theories be combined to evoke an emotional experience in the built environment?

1.3 Aim

The purpose of this report is to demonstrate how a new type of pavilion can be used in a landscape environment (DeBoer et al., 2016). By combining design innovation and biomimicry to make a spatial experience, the pavilion can be delivered as a sustainable, meaningful spatial experience. This is to ensure that the spaces offered are suitable for the population's use, and that the well-being of those using the public site increases. Through exploration, the study aims to discover an effective way to appeal to the emotions, at the same time as giving an active space experience. This is perfect for those in need of some relaxation, entertainment and spatial experience.

1.4 Problem and Opportunity

The research problem highlights the idea of a pavilion design for individuals to explore. Visitors can spend time sitting and viewing the surrounding environment. Putting the pavilion at a vantage point and creating some unique features can attract more visitors. As Susan Hatchell (2012) previously claimed, “A pavilion is a crucial space of getting people outside”. Landscape architects place the shelters to attract people to look at and walk around them, and they are normally placed to afford wonderful views across the landscape beyond. Pavilions can offer a place to rest, and also act as a shade to shield us from excessive exposure to the sun. They are intentionally created to be accessible. Consequently, all ages and abilities will enjoy a fabulous scene outside. Pavilions offer a central location for a friends’ gathering, as well as large family reunions. Pavilions also serve as outdoor classrooms, performance spaces, or as a peaceful place to read, sketch, or play instruments while enjoying outside. Much landscape architecture, for example the Elytra Filament Pavilion, can successfully show these uses. However, nowadays, most people’s impression of a pavilion is that they are just like shadows. People have a short break or shelter in them. The pavilion cannot provide a higher value than this for the public to enjoy. As a result of this problem, public spaces cannot offer an enjoyable outdoor experience for the population.

Recently, bio architecture has become an accessible technology which has been used for research in architecture and engineering, partly as a result of the fact that it offers a solution that is a more continuous and reproducible architectural environment, and also it is an inspirational source for aesthetic expression. Therefore, exploring how bio architecture can be designed and used to promote the function of the pavilion gives a significant chance of innovation.

2. 0
Literature Review

Definition: the literature review

Hart (1998) defined the literature review as "the use of ideas in the literature to justify the particular approach to the topic, the selection of methods, and demonstration that this research contributes something new" (p. 1).This project focuses on the relationship between the public and landscape architecture in the urban environment by providing a pavilion to create a meaningful experience for the public. One of the leading aspects of my research is user-centered design,which can be used to explore and evaluate the needs of users. It mainly involves the function of open space, individuals' satisfaction in the area being studied and the prospects for a new product. Research included reviewing the literature on different types of pavilion, and this literature methodology would build a firm theoretical foundation for my study. As Webster and Watson (2002, pp. 48-49) state, a host of previous literature is an essential incentive for any academic problem's solution.

The necessity of unmasking the knowledge that existed before the start of any research study should not be undervalued (Hart, 1998). For this reason, the literature review provides an effective method to conduct research.

The benefits of a literature review for my research are in:

- Helping the researcher to understand the existing related knowledge, which includes what knowledge is already known and what experience is necessary to develop new knowledge.
- Providing a firm foundation regarding what is already known in the research.
- Confirming the existence of current research problems.
- Devising an effective way to support the text and conduct the research.

2.1 Origin of Biomimicry

2.1.1 History of Bomimicry

The terminology ‘biomimicry’ was invented and disseminated as early as 1982 by scientist and author Janine Benyus, as explained in her work, Biomimicry: Innovation inspired by nature (Benyus, 1997). The definition of ‘biomimicry’ in her book was a "new science that surveys nature’s models and then gets imitation inspiration from these designs and processes to solve problems for human beings". Benyus expected to look to nature as a "Model, Measure, and Mentor" focusing on sustainability as an aim of biomimicry.

Moreover, the term “biomimicry” has been applied since the 1960s when Otto H. Schmitt stated his definition of “biology+technology” but he used it mainly in the engineering field. In the architectural field, however, biomimicry has been applied only since the 2000s, restating biomimetics as a key to design (El-Zeiny, 2012).

2.1.2 What is Biomimicry?

Biomimicry is a subject that stresses design by imitating flora, fauna or whole ecosystems. Maibritt Pedersen Zari (2007) classified biomimicry into three different categories or "levels": Organism, Behavior, and Ecosystem. Diverse approaches to the use of biomimetics as a design process are under discussion in the literature. These methods either: (1) identify a design problem and examine the ways in which organisms or ecosystems have solved it, or (2) identify a specific trait in a body or ecosystem and translate that into a design that can work out a human problem. The former can be considered as a top-down, problem-based approach, or "design looking to biology," and the latter a solution based, bottom-up approach, or "biology influencing design" approach (El-Zeiny, 2012; Pedersen Zari, 2007). For either of these methods to function, a framework for the application of biomimicry is necessary.

Varying perspectives exist in the literature. For instance: form, process, and ecosystem have been considered as different levels of mimicry (A biomimicry primer, 2012).

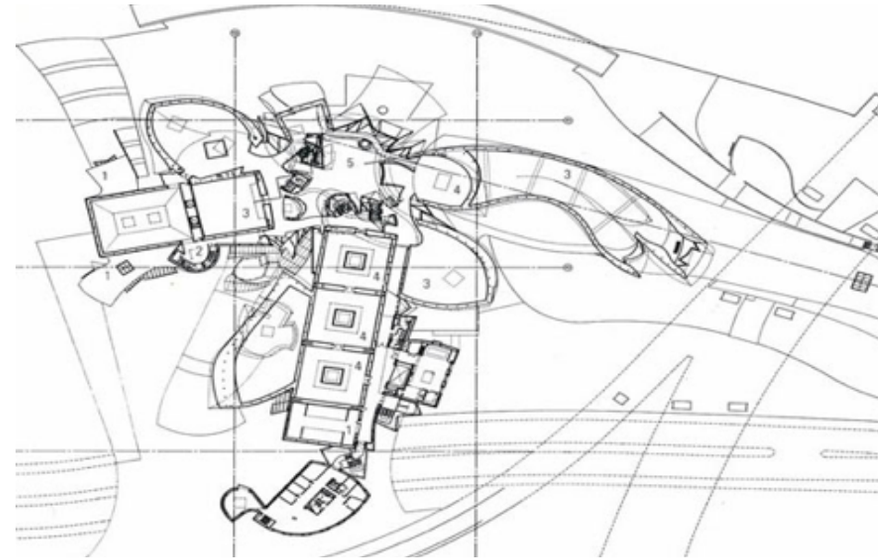
Other ranges with diverse dimensions are also explored: organism, behavior, and ecosystem (Pedersen Zari, 2007). In reality, a design could make imitations of the traits of an independent organism, which may be inspired by how the organism acts, or the design may draw from the whole ecosystem of an organism and its surroundings. This technology has become prevalent in research in architecture and engineering. This is partly due to the fact that it is a suggestive content for the innovative concept, and because it offers a way that a building surrounded by creation is developed sustainably and regenerative.

2.1.3 Biomimicry Approaches

It is evident from different methods of biomimetic design that each approach has its intrinsic merits and demerits. Moreover, these distinct methods might have significantly diverse effects on the whole sustainable development. However, some designers and scientists use biomimicry as an approach to tackle a design problem. At the same time, biomimicry can be considered as a source of innovation in some situations. From the perspective of the lifecycle, biomimicry design approaches do not mean the final product or material will become more sustainable than traditional methods. Usually, biomimicry as a design process is split into five categories, e.g.

2.1.3.1 Simulation

This takes place through mimicking or copying the outward appearance of forms in nature. At the same time, the characteristics of most buildings are simulated by expanding the scale of nature's ways. Buildings were not expected to aspire to any environmental responsibility. However, none of the more extensive environmental responsibilities of nature were supposed to be required of buildings. This direct learning from natural forms was not expected to do useful work as nature does. The purpose of this simulation approach is natural imitation realized, while technology might create valuable tools to accomplish it. The use of a simulation approach is not new. Some ancient civilization buildings, such as Greek and Egyptian historical building elements,were constructed in natural forms. At the same time, the Guggenheim Museum (Fig. 1) is a simulation case, where the attributes of the fish and the snake have been abstracted and subtly transformed.



[Figure 1] The Guggenheim Museum, Bilbao, by Frank Gehry (1997)

2.1.3.2 Interpretation

Structural Interpretation

This approach mainly focuses on using the minimum of materials, and a high structural strength as realized in natural forms. The use of excellent materials helps buildings with a low energy system. So, this sort of architecture can be maintained for a long time.

System Interpretation

1) The intention of this approach mainly concentrates on achieving a comfortable condition.
2) The system of biomimicry utilizes the surrounding energy and decreases the consumption of fossil fuels.
3) It is a way for people to minimize ecological impact.

2.1.3.3 Integration

This approach helps to tackle efficient systems that come from nature, enabling the buildings to work efficiently and with the ecosystem. It aims at achieving the integrated functionality of nature and fitting form to function. This approach arrives at a low-energy building that would work efficiently with nature's dynamic systems. This approach is primarily intended to make a combination of the notion of biomimicry, and put it together to form a cohesive whole, as a building system which features efficient energy saving, and also specifically to centralize the tectonics that comes from natural forms. Because of the process of generation, the trends of nature, functioning reflexivity and conversion keep to a higher principle of integrating forms and complete the whole.

2.1.3.4 Replication

Replication is referred to as “primary biomimicry.” In this natural process, replication is not achieved by mimicking exact solutions, such as organic shapes, patterns, structure, and functions, but by considering it as a coherent entirety. In nature, some plants have a similar ability to organisms. These organisms usually can complete the process of metabolism. The buildings could be regarded as a system which is self-regulating and adapts to changing environmental conditions. Thus, the structures could have the ability to self-regulate and to maintain internal balance, just like organisms do. For example, the lotusleaf has the ability to self-clean, and the step of self-cleaning by duplicating the Nano-surface of the lotus leaf is applied to the surface ends of buildings, such as surface paints and wood surfaces. Thus, there is a possibility that the surface treatment would have the ability to self-clean in the future and avoid toxic cleaning products, allowing it better environmental protection.

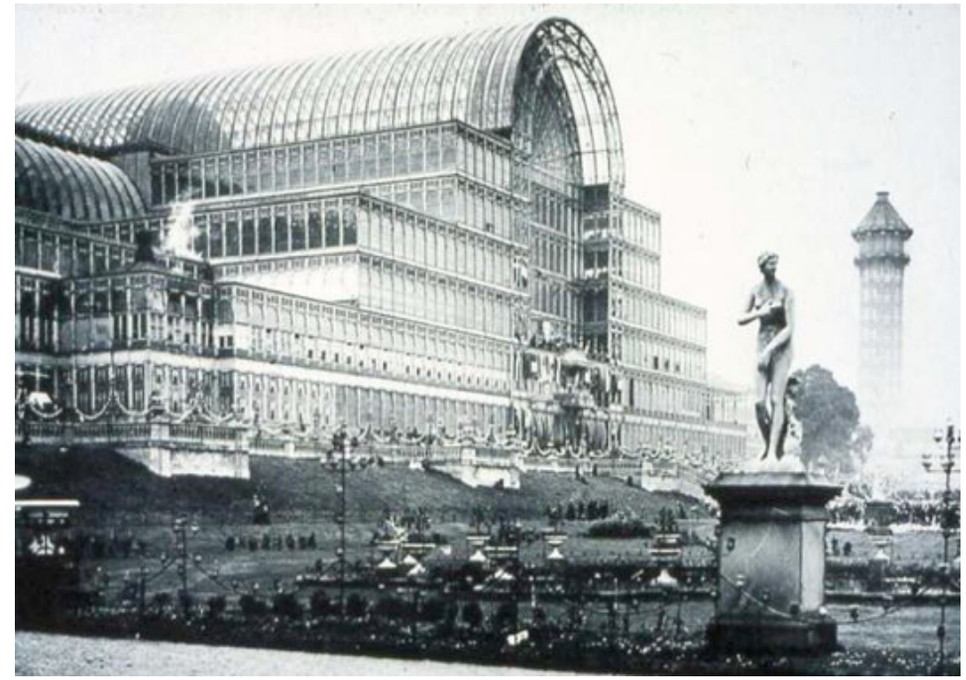
2.1.3.5 Emulation

Emulation can be called “advanced biomimicry.” It is mainly derived from modelling natural processes to the degree of self-assembly and self-repair leading to a holistic, integrated functionality, such as occurs in natural systems. In this rank of biomimicry, a building can be regarded as a living system that can self-assemble.

2.1.4 Application of Biomimicry in Different Fields

2.1.4.1 Biomimicry in Architecture:

Biomimicry is widely used in architecture. There is an example which happened in 1851 when James Paxton intended to develop the structural system of the Crystal Palace (Fig. 2) from his finding of giant water lilies. Not surprisingly, the flowers in the lily collection in Strasbourg inspired him. In the middle of the 20th century, Robert Le Ricolais, a professor from France working at the University of Pennsylvania, deepened structural models by imitating biological structure models that were once applied by Haeckel, a biologist from Germany in the 19th century.

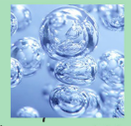


[Figure 2] Crystal Palace by James Paxton.

[Figure 3] Falling water by Frank Lloyd Wright.

Also during the 20th century, many people working in this field, such as Le Corbusier and Frank Lloyd Wright, obtained inspiration from nature. Frank Lloyd Wright specified organic architecture in his works. However, at the same time, he did not include nature as a predominant factor (Fig. 3); this figure mainly illustrates how he applied the natural element of water in the falling rain. His overall philosophy was that architecture existed to be nature-friendly. As Le Corbusier declared, biology was expected to be "the great new word in architecture and planning" (Steadman, 2008, p. 2).

2.1.4.2 Case Study

Name of building	Inspiration	Application in design	Problem solved	Level biomimicry
 Eiffel Tower	 Thighbone	-The outward flare resemble that of a femur bone. -The lattice is built from metal from metal studs and braces.	-Withstands bending and shearing effects due to wind. -Ventilation problem solved.	Organism Level
 Eastgate Center, Harare	 Termite Mound	-Contains etfe panels that insulate by stuffing small pieces of materials in the twigs. -Panels protect and provide sunlight filtration.	-Panels reduce the dead load supported by the foof. -Cost reduction, recyclable. -Facade openings allow for natural ventilation.	Behavior Level
 National Aquatics Center, Bejing	 Water Bubbles	-The surface is covered with membrane of pneumatic cushion created from ETFE allowing for the bubble effect.	-The bubbles collect solar energy -Allows for temperature regulation.	Organism Level
 Hok, Lavasa, India	 Fig Leaf	-Foundation stores water. -Drip tip system water to clean its surface.	-Responds to the seasonal flooding. -Moves excess water.	Ecosystem Level
 Bejing National Stadium	 Birds Nest	-The center opens and draws more air to help fans and is pushede up through ducts that are located in the center of building.	-Temperature is regulated throughout the year with no need for HVAC systems.	Behavior Level

[Table 1] Radwan et al (2016) Applications of Biomimicry in architecture.

2.2 Biophilia

2.2.1 What is Biophilia?

In 1984, the biophilia hypothesis was introduced and promoted by E.O. Wilson (1984). This hypothesis denied biophilia is the urge to be a slave to other life forms (Kellert & Wilson, 1995, p. 416); the premise of Wilson's Biophilia claimed that there is a natural link between humanity and other life systems. Biophilia, however, is the theory. Biophilic design as proposed by Kellert et al. (2008) and Beatley (2011) provides a globally sustainable design method that strives to reconnect the natural environment with human beings. Biophilia, which could be interpreted as "love of life", means that the requirement of individuals' inherent emotions and biology is associated with nature. Biophilic design ia can establish this relationship (Fig. 4) through the application of examples in life and patterns in nature to improve health and well-being in the urban built environment.

Recently, Browning, Ryan and Clancy (2014) suggested "14 patterns of biophilic design" (Table 2) within an efficient framework for the relationships between human biological science, natural and built environment design.

1)NATURE IN THE SPACE

Vatican City Gardens
Image: Valentina A/ Flickr.

2)NATURAL ANALOGUES

Suites Avenue
Image: Asla/Flickr.

3)NATURA OF THE SPACE

Fort Worth Water Garden
Image: JayRaz/Flickr.

[Figure 4] Design-nature relationshaps

Nature in the space	1 Visual connection with
	2 Non-visual connection with nature
	3 Non-rhythmic sensory stimuli
	4 Thermal and airflow variability
	5 Presence of water
	6 Dynamic and diffuse light
	7 Connection with natural systems
	8 Biomorphic forms and patterns
	9 Material connection with nature
	10 Complexity and order
Natural analogues	11 Prospect
	12 Refuge
Nature of the space	13 Mystery
	14 Risk/Peril

[Table 2] BROWNING et al (2014) 14 patterns of Biophilic design.

2.2.1.1 The Interpretation and Inspiration of Patterns.

[Figure 5]

Figure 5: Dynamic and diffused light dynamics, and dispersive light power change the strength of light and shadows that very gradually lead to conditions occurring in nature.

[Figure 6]

Figure 6: Biomorphic forms and patterns are typical evidence to outline the pattern-grained numerical permutations that exists in nature.

[Figure 7]

Figure 7: Material connection with nature is the substance of natural elements. With minimal management, it can suggest the local ecology or geology, which can locally create a sense of can create local sense of connection.

[Figure 8]

Figure 8: Complexity and order is full of sensory information attached to a spatial level, which is similar to those occurring in nature.

2.2.2 The Significance of Biophilia

What is the significance of biophilia to the population? Research in environmental psychology and neuroscience illustrates how independent elements and circumstances in nature can significantly benefit people's health and happiness. Biophilic elements have been identified to feature stress reduction, cognitive performance improvement, and positive emotional support and mood. Thus, biophilic design applies science to create healthful spaces in a range of places, from schools and working space to hotels and city streetscapes.

2.3 The Differences and Overlaps Between Biomimicry and Biophilia

Biomimicry and biophilia are fundamentally similar because they are both derived from the environmental movement. At the same time, they both have a secure connection to nature. However, their goals differ significantly at a conceptual level. Understanding their differences and their potential to deal with problems is key to opening the breadth of results that nature has to

offer from long-term developed, creative designs in terms of better health conditions for people and their mental happiness. So how do they differ? In short, biomimicry can to some extent convert to "mimicry" with more precision, and end up with the emulation of life's engineering. By contrast, biophilia describes humans' link to nature and biophilic design replicates experiences of nature in design to reinforce that link. Biomimicry is an innovative method to achieve better performance; however, biophilic design is an evidence-based design method to improve human health and mental happiness. In essence, these two notions derive fromnature in different ways. Biomimicry considers the innovation potential of life's tested-and-true "technologies." Biophilia identifies the health benefits of human biological consistency with nature. They both display multiple inspirations that we can learn from nature. Moreover, it is important to ask what is similar? People who are familiar with this field may argue that there is no clear-cut distinction between biomimicry and biophilia. Biomimicry and biophilia overlap, for the reason that most designs of two applications may come together in bio-morphism, or mimic the natural form.

[Figure 9] Landesgartenschau Exhibition Hall by Achim Menges (2014)

Take the striking Landesgartenschau Exhibition Hall (Fig. 9) as an example; the exhibition hall by Achim Menges at the ICD Universität Stuttgart, which derives its lightweight form and paneled construction from the sea urchin's shell morphology of interlocking bony plates. It is undoubtedly biomimetic because the sea urchin inspired its structural characteristics. It is also biophilic because it possesses characteristics of biomorphic forms and patterns (Browning et al., 2014).

2.4 Spatial Perception

2.4.1 Conception of Spatial Perception.

The different orientations between the terms biomimicry and biophilia were discussed by Harrison and Dourish (1996) adeptly: "Space means the structure and the geometrical features of a physical environment" (p. 67-76). On the other hand, place may refer to the dimensional extent, which includes life experiences, interaction and the usage of space. In fact, constructed from the perspective of phenomenology, this understanding emphasises the meaning that spaces are obtained by active and concerned participation in them. This makes these spaces into meaningful places in a social manner; thereby, physical space can be regarded asa place, for it provides specific activities. Meanwhile, in this particular space, people could realize their spatial perception. To relate to the surrounding environment and themselves, spatial perception consists in people recognising space by way of human senses. That is to say, human beings could get proper information about the characteristics of their surroundings through, for example, visual systems, haptic systems and distinct feelings. Among these, the most evident space is visual perception.

2.4.2 A Study of the Traditional Pavilion

A traditional pavilion (Fig.10) built by Confucian scholars was not a place merely to recite poems or enjoy drinking but a place for the scholar to engage in philosophical debates. So, a traditional pavilion can be a specific space, where scholars can realize academic discipline and emotional relaxation.

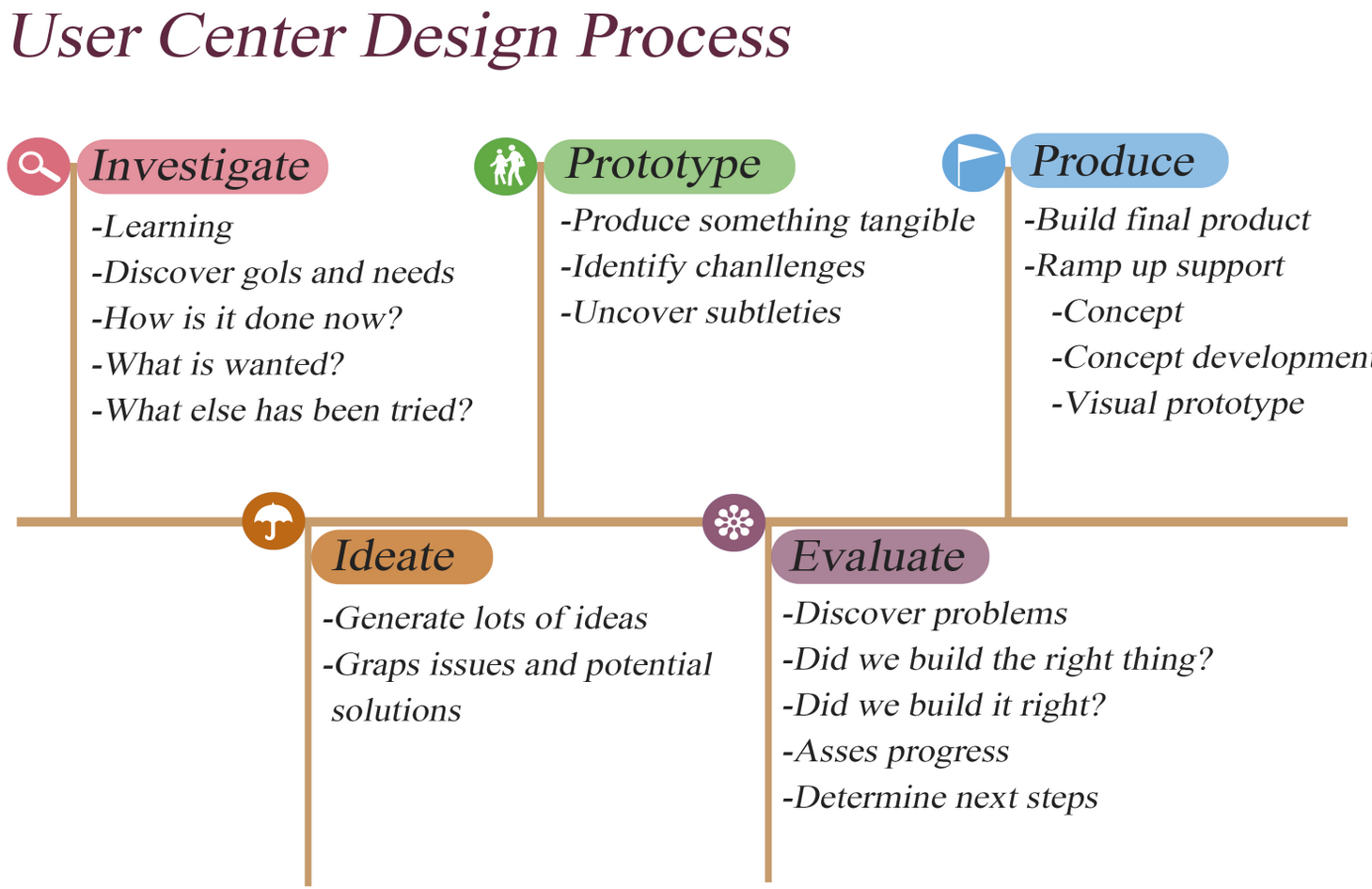
[Figure 10] Traditional pavilion

A traditional pavilion itself mainly focuses on providing a space for enjoyable relaxation; it was often considered as a part of garden facilities and established according to the surrounding environment or geographical conditions. There is no particular design in the spatial perception. Therefore, based on a study of the traditional pavilion, when related to my pavilion design, I prefer using elements from biomimicry and biophilia as they are not only in a natural form but have visual perception. For modern architecture, in addition to emphasizing the role of building itself, spatial experiences and external appearance are introduced into building the traditional pavilion.

3. 0
Methodology

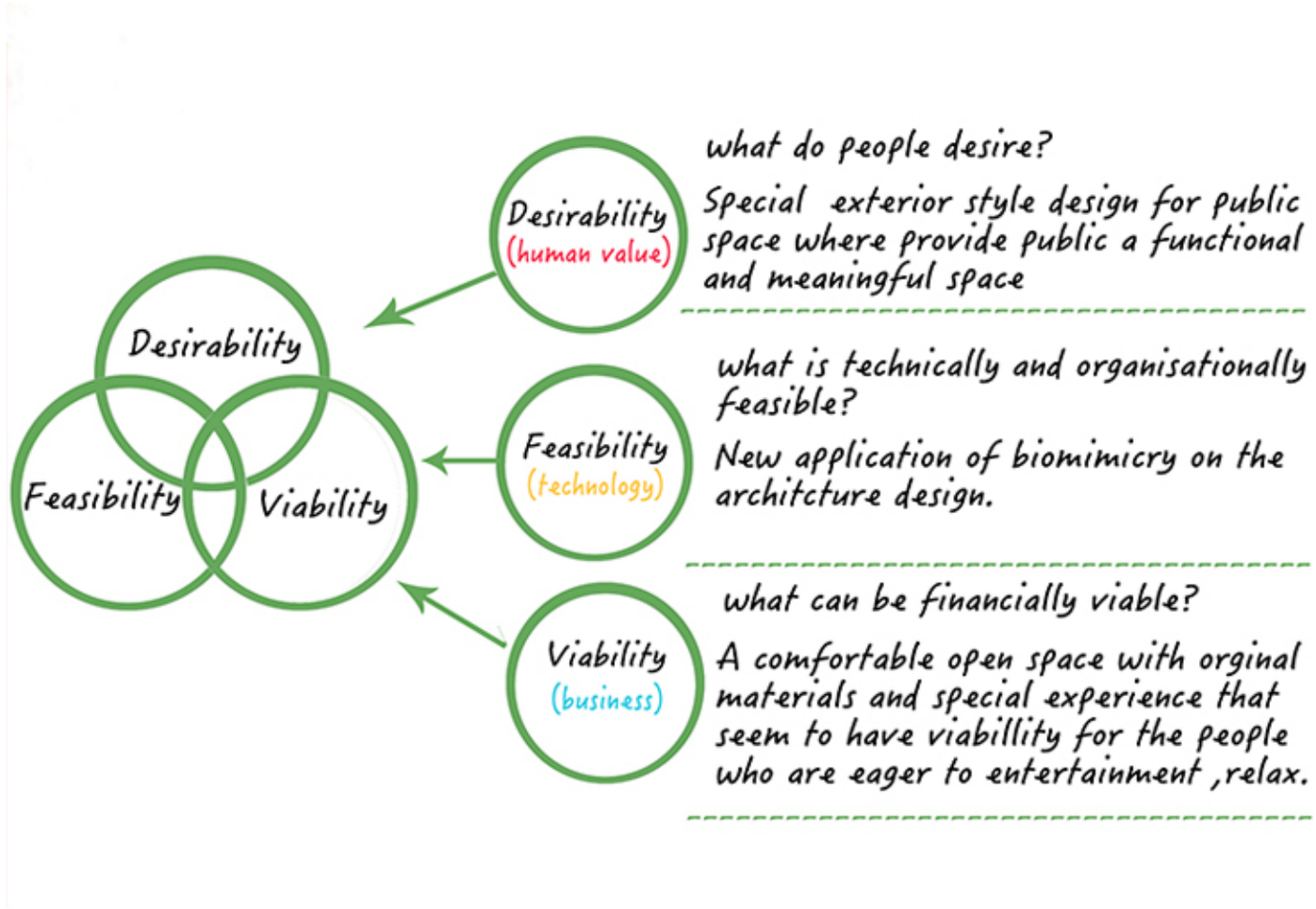
A multi-methodological framework was developed for this study. This methodology will use mixed methodologies to gather information to inform my design.Since I was designing for human experience, the primary method was human-centered design which helped me to develop a space that is desirable to the users, and is technically feasible and financially viable. These three design goals were essential for me to follow, as they were the critical objectives for guiding an innovative outcome for my design project. However, human-centered design by itself could not produce optimum results. It was supported by a phenomenological methodology that was applied to understand, describe and interpret the users' culture, needs and wants. The mixed methodological framework was further supported by design principles and models, such as the Four Pleasures of Design, and other necessary psychological, emotional and experience design theories. For information and insights, I sought to capture my design from art, science, and technology. However, one of the critical methodologies I applied in the design process (design practice) was heuristics. It was aligned and integrated with other research methods, such as literature review, ethnography and observation, to generate information to guide the design practice.

3.1 Human Centred Design



[Figure 11] User center design process, illustrated by Gao (2018).

The design of the developing physical and social spaces using biomimicry is a very emotional research and design study. One of my methodologies to generate essential information knowledge and insight to form my design is user-centered design (Fig. 11), because the design of my space would be central for developing the environment that gives my users meaningful experiences. According to many articles, 'User-centered design' (UCD) is a generalized term to describe design processes in which end-users affect how a design can be shaped. It is the most important part of my biomimicry design. However, user-centered design is a broad concept for myproject. There are various methods in which users are involved. For instance, I would consult individuals about requirements and needs at a specific time during the design process. Therefore, the user would be the central part of the development process of my public space since the purpose was to provide the public with a functional and meaningful space. The procedure is draw on individuals' opinions to analyze, explore, design, and evaluate. Thus, the space may be more efficient, safe and practical in serving people's needs. To identify a meaningful, human-centered experience design for space, three lenses (Fig. 12) should be involved in the delivery and evaluation of a successful experience.

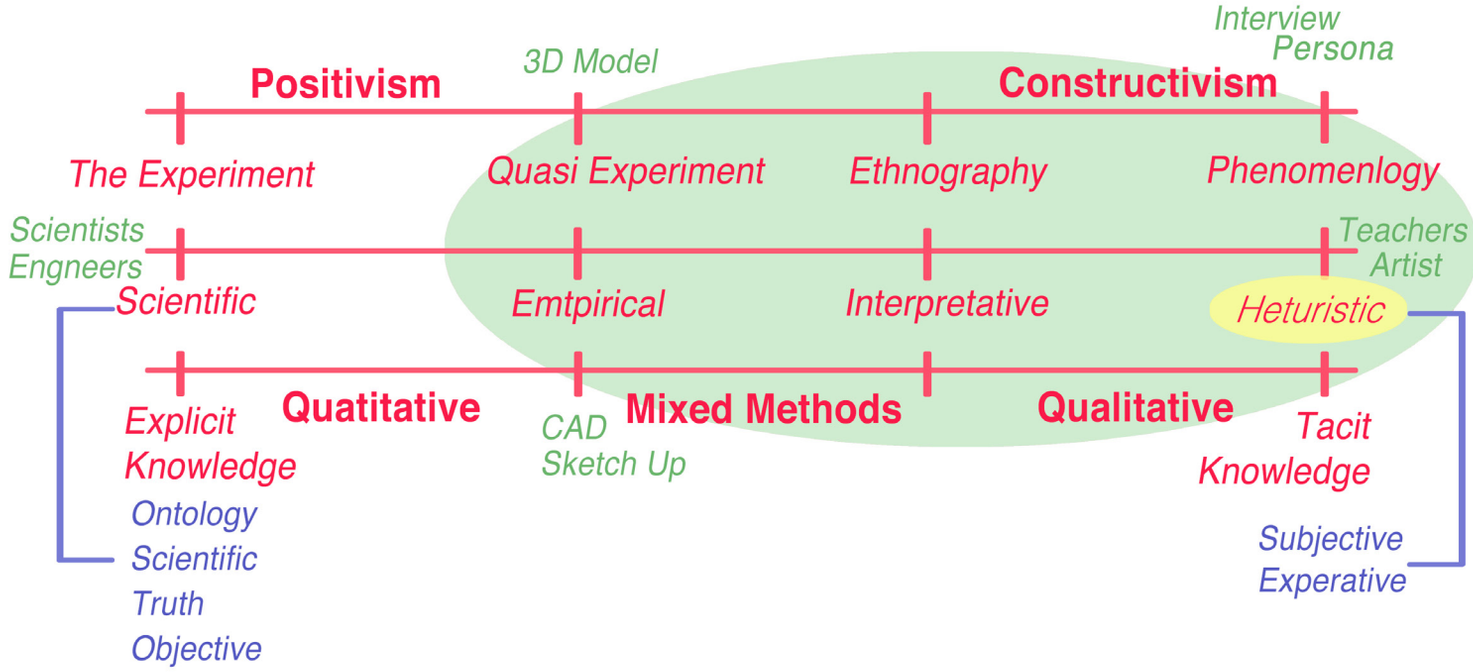


[Figure 12] The three lenses of human center design, illustrated by Gao (2018).

3.2 Phenomenology

There are two standard ways of leading research, as shown in Figure 13, qualitative and quantitative data collection (Yap, 2017). These two research methods are generally committed to fundamentally different approaches of looking at the world. Qualitative analysis typically is exploratory and investigative; its findings are often not conclusive and cannot automatically be used to make generalizations. However, it is indispensable in developing a deep understanding of a given thematic complex and a sound rationale for further decision making. Quantitative research is essential for providing a broad base of insight on which a final course of action is recommended.

The phenomenological methodology is a qualitative research approach. It is significant for the landscape architecture designer and user-centred designer. In relation to my project, using phenomenology, I thought that it would help me to have a deep understanding of the visitors' perspective. I wondered what forms can provide viewers with a different effect, such as a different visual effect? To be more specific, I was asking what is the most meaningful experience? In the human sphere, this normally translates into gathering 'deep' information and perceptions through inductive, qualitative methods, such as interviews, discussions and participant observation,



[Figure 13] The research methodology of the proposed research design project adopted from Yap (2017).

and representing them from the perspective of the research participant(s), as they are powerful methods for grasping subjective experiences and gaining insights into people's motivations and actions.

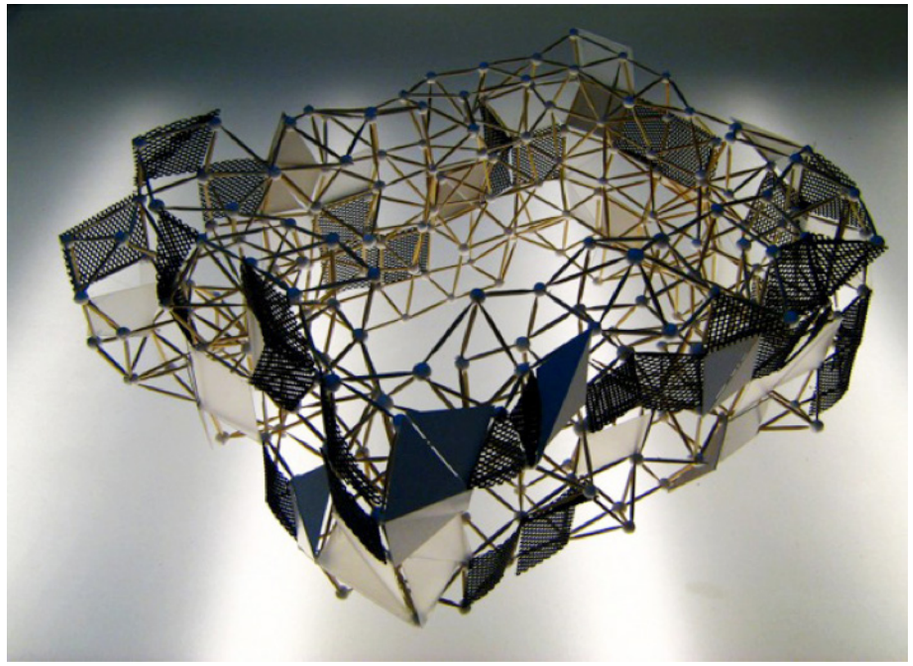
In this project, I employed the phenomenological methodology to seek perspectives of individuals and a depth of understanding of human behavior, experience, intentions, and motivations.

3.3 Heuristics

One of the critical methodologies I applied in the design process (design practice) is heuristics. Heuristics are strategies that come from former experience with similar problems. These used to rapidly come to a solution that is expected to be the approach to the most likely answer, or "optimal solution." The most common heuristic is trial and error, which can be used in everything from matching nuts and bolts to finding the values of variables in algebra problems. The actions of my practice are based on a trial and error design process. As the design process is at the centre of my training, a good understanding and application of heuristics is very significant. My research used mimics to induce a spatial experience, so I needed to explore and learn about the relationship between mimics, landscape architecture, and the space experience. The first thing I needed to do was to understand and learn about biomimicry, as well as the application of biomimicry in landscape architecture. Secondly, during any learning process, we should explore the test step by step, and find out the relationship with the surrounding environment; in this research, history and culture, as well as biomimicry, are related factors. Through this method, it was possible to clarify the relationships among concepts of nature, technology, and the built environment so that I could broadly feel the human benefits of biophilia and biomimicry in design applications.

3.3.1 Internet Ethnography

Internet ethnography is a new methodology for valid and published research online, based on the integration of qualitative data gathering methodologies both online and offline. This methodology is used to explore the relationship between the human and the public space, and then provide extra online information, which could create reasonable literature evidence to support my research. The following case studies come from the use of internet ethnography and relate to my research.



[Figure 14] The design of geometry structure by MAB Studio.

- MAB Studio (Achawin Laohavichairat) use biomimicry as an inspiration to make the landscape building (Fig.14); the purpose is to create a building in harmony with the surrounding environment. This building uses biomimicry strategies that integrate form, material, and structure into a single process. By observing and studying the behavior of nature, the structure comes from the geometry of natural structures; what is more, the construction of the building is a lightweight structure.

[Figure 15] The design of “eye-beacon” by UNStudio and MDT-tex.

• The design of “eye-beacon” by UNStudio and MDT-tex (Fig.15), who have tapped into the ocean’s murky depths for their design. The design of this pavilion followed the theme of biomimicry. The colorful art installation was inspired by the bioluminescence of deep-sea creatures; it uses illuminated LEDs that create a pulsating effect to imitate the deep ocean glowing creature. In this way, a type of colorful pavilion could develop in visitors a sense of travelling in the deep sea.

3.4 Research Methods

3.4.1 Observation

Observation is watching what people do; it seems to be a direct method of accomplishing research in psychology. However, there exist three different observational methods: controlled observations, original observations and participant observations. I applied a naturalistic view to the conduct of my research. Naturalistic observation involves participants' spontaneous behavior in a natural environment, where the researchers can only record what they see from observing the participants. Using this method to record the actions of people in a public space would allow a researcher to find out which space they like to stay in or what they prefer to do in the open space. Naturalistic observation was considered to be more concrete for this project, partly because it has a higher efficiency by being able to observe people's behavior in a comfortable way. In general, research needs a long time to find more participants, which could allow the researcher to gain more reliable information about different types of people's activities. Meanwhile, it also requires research into various types of open spaces, which could help researchers gain a deeper understanding of what kind of public space people prefer. However, there also exist some limitations; these observations are often small-scale, while people often have different character traits. These other variables cannot be controlled. Furthermore, the researchers may lack the comprehensive awareness, which may mean they tend to see what they want to see.

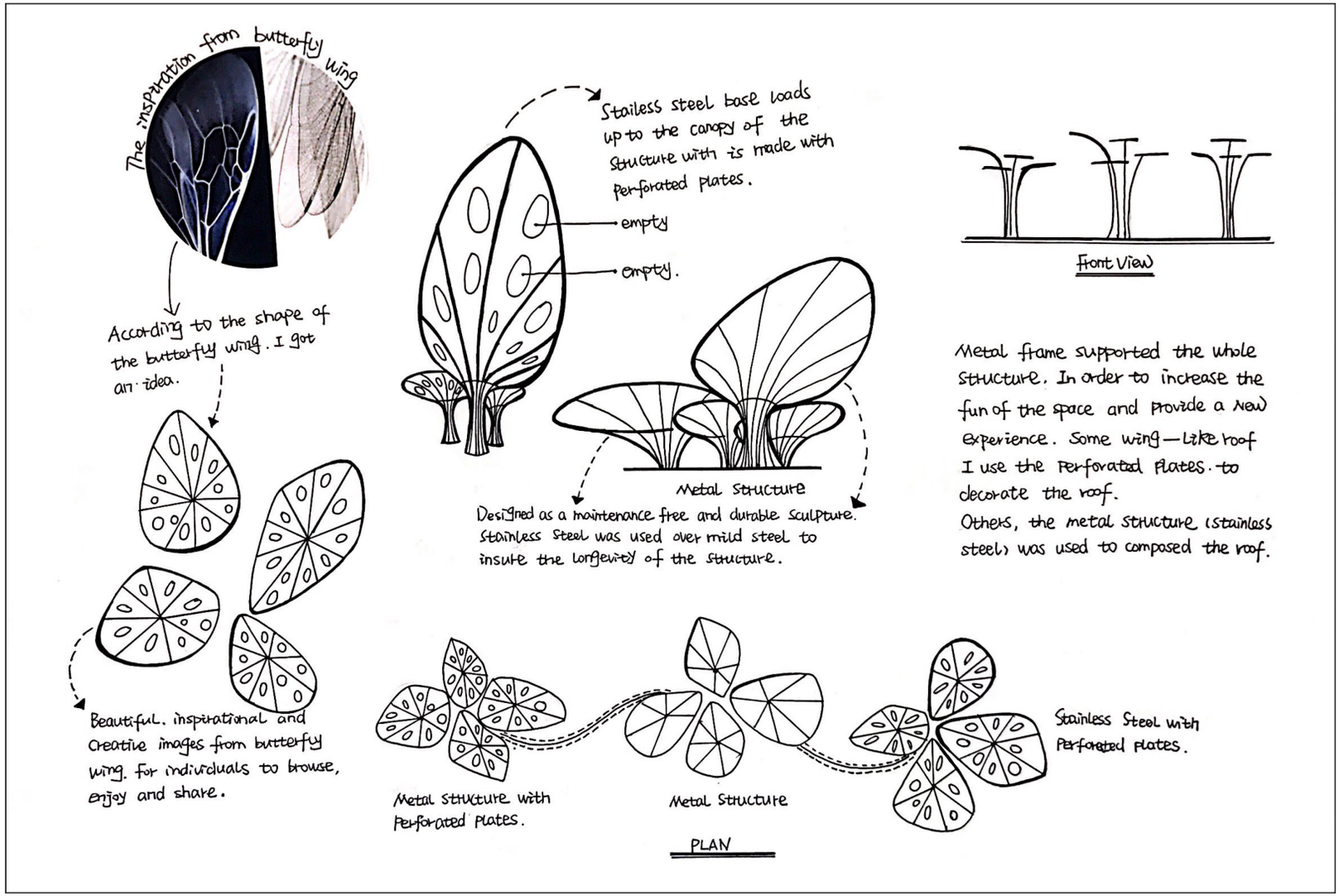
3.4.2 Survey and Interview

A questionnaire is a significant approach for gathering information. In my project, a practical and useful questionnaire was used for data collection. I used a poll to survey attitudes towards open space and the space experience, as well as different emotions connected to various significant events. The interview is a direct way to collect information. We can gather some very insightful stories from participants. In my project, the potential participants were chosen in an outdoor space, with a random objective. Firstly, interviewing the person in the public space was efficient approach to understanding the experience of space, the emotions as well as the expectation of open spaces in the urban environment.

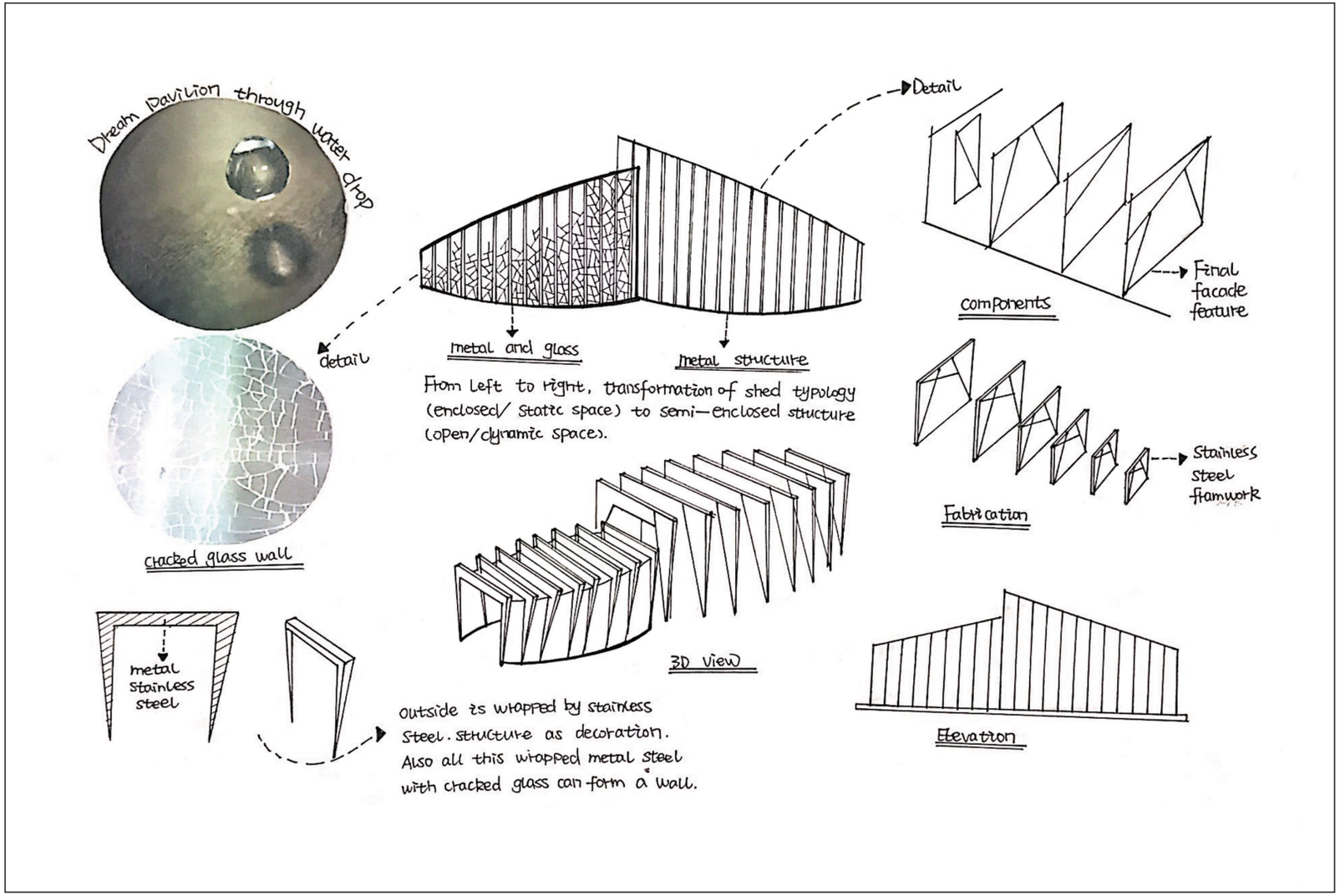
At the same time, a meaningful space experience will be designed. Similarly, if the researcher can interview a person with strong demand for outdoor space, the researcher will get more information about how the experience design can be more emotional, meaningful and sensory for that person.

4. 0
Concept & Design Development

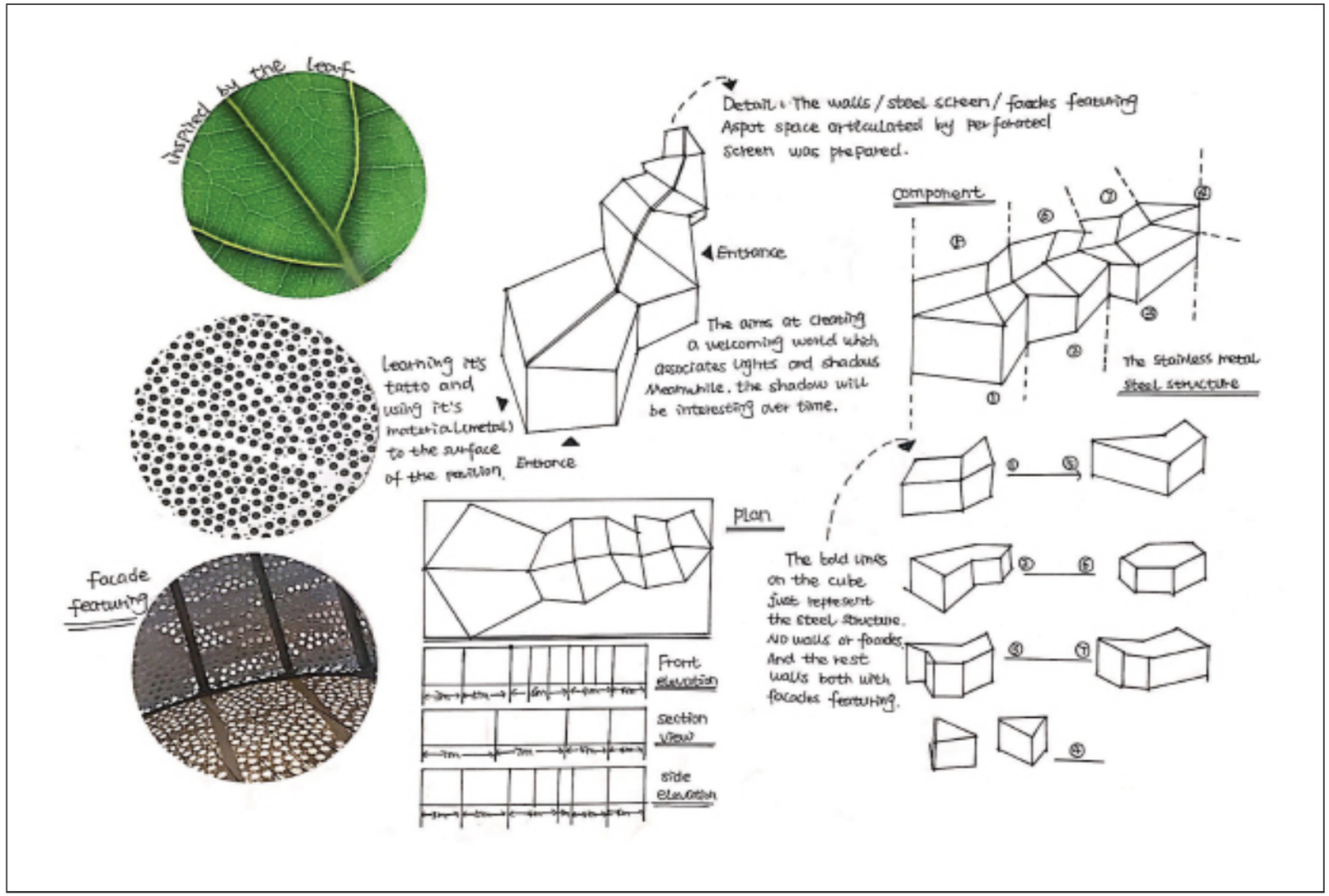
4.1 Concepts



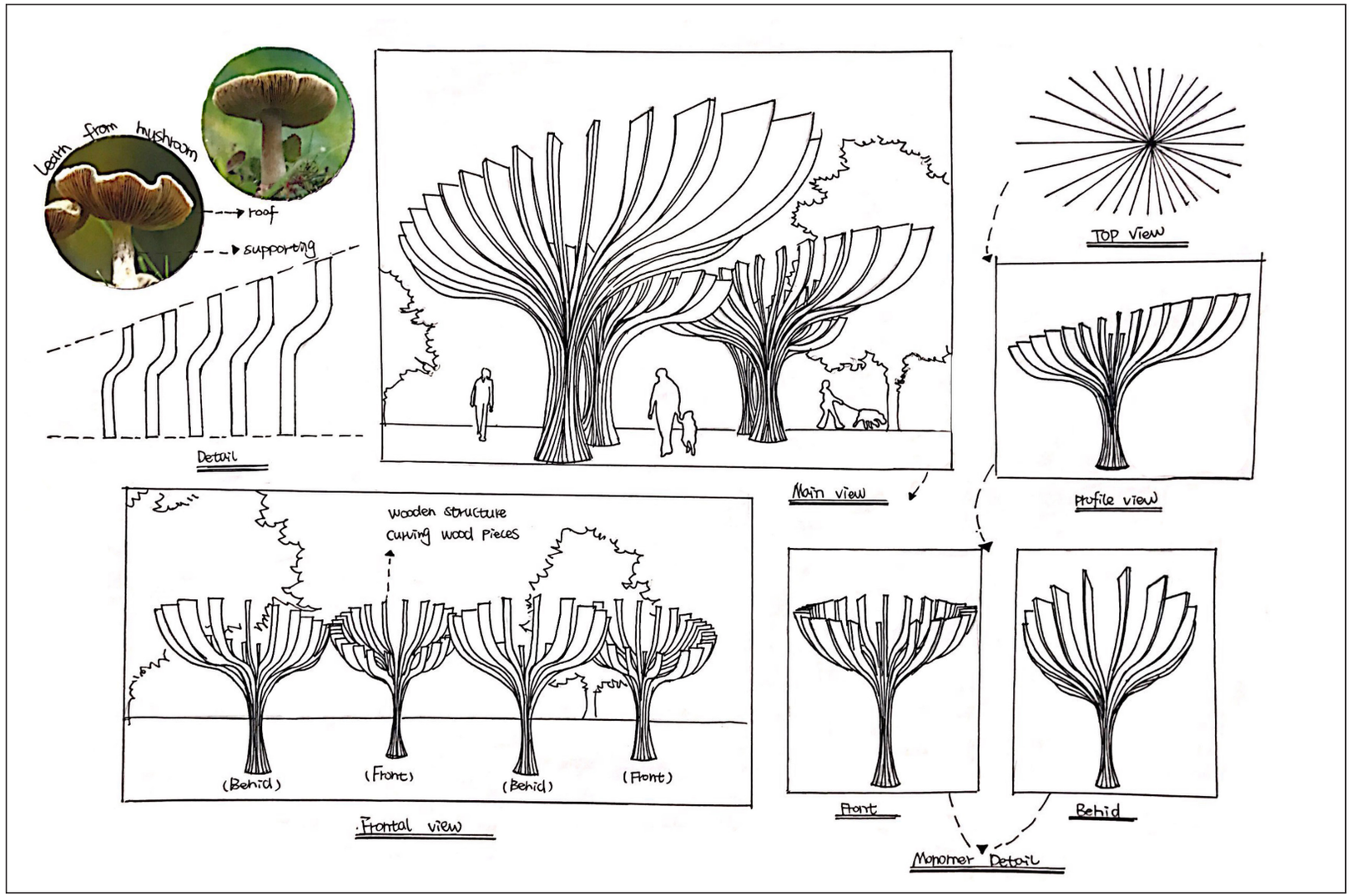
[Figure 16] Concept 1 inspired by the wing, sketched and illustrated by Gao (2018).



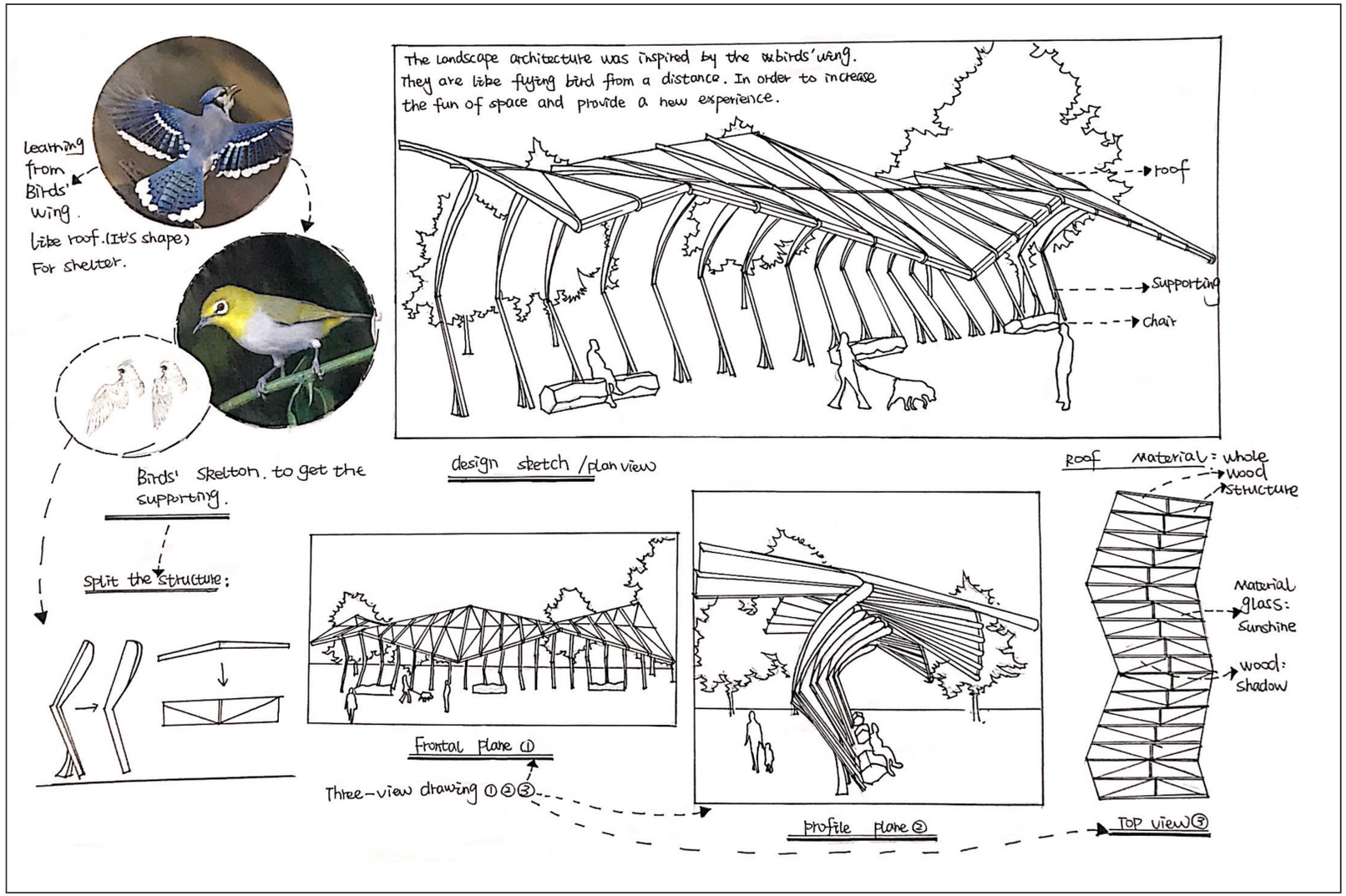
[Figure 17] Concept 2 inspired by water drop,
sketched and illustrated by Gao (2018).



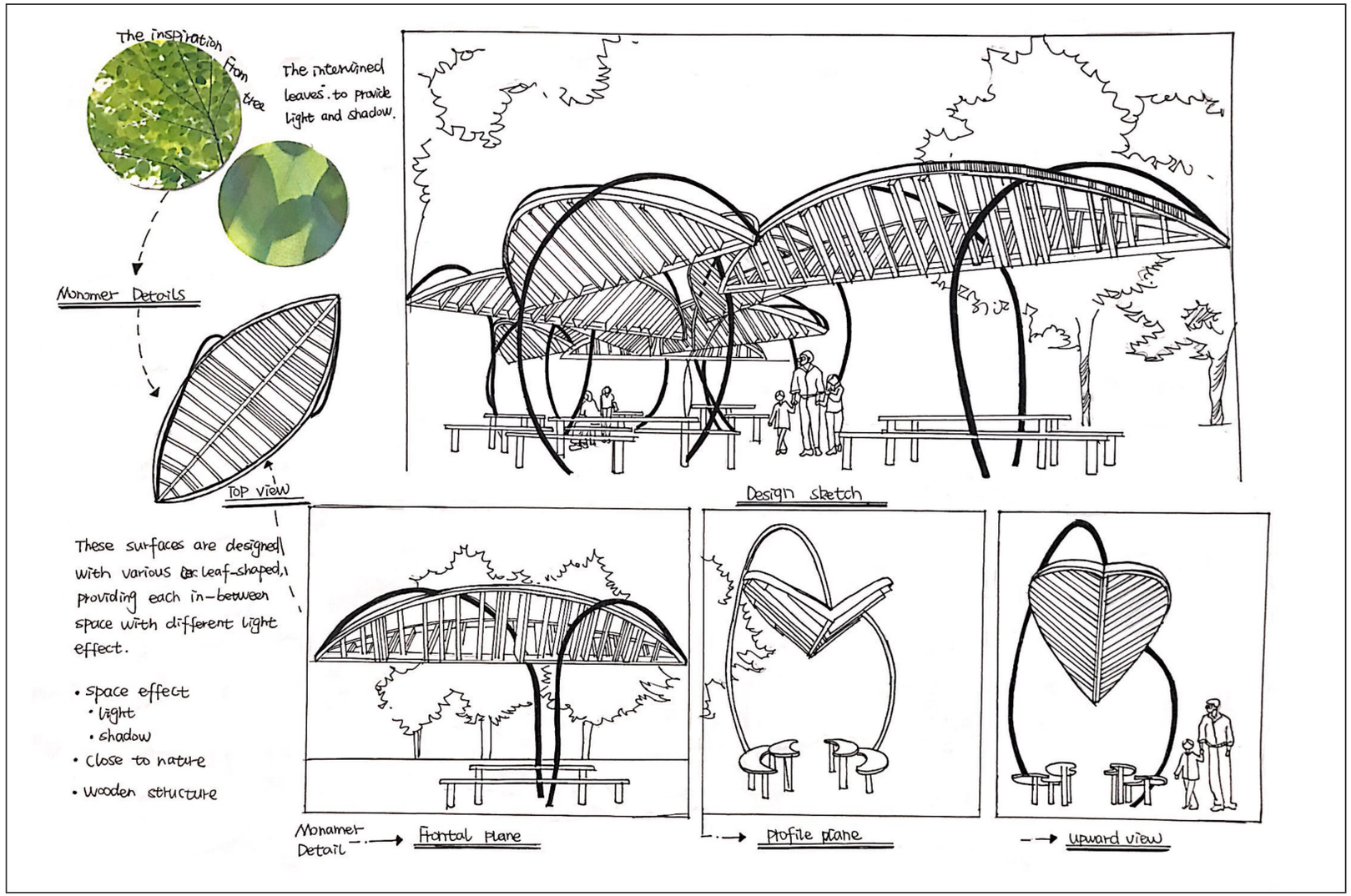
[Figure 18] Concept 3 inspired by the leaf,
sketched and illustrated by Gao (2018).



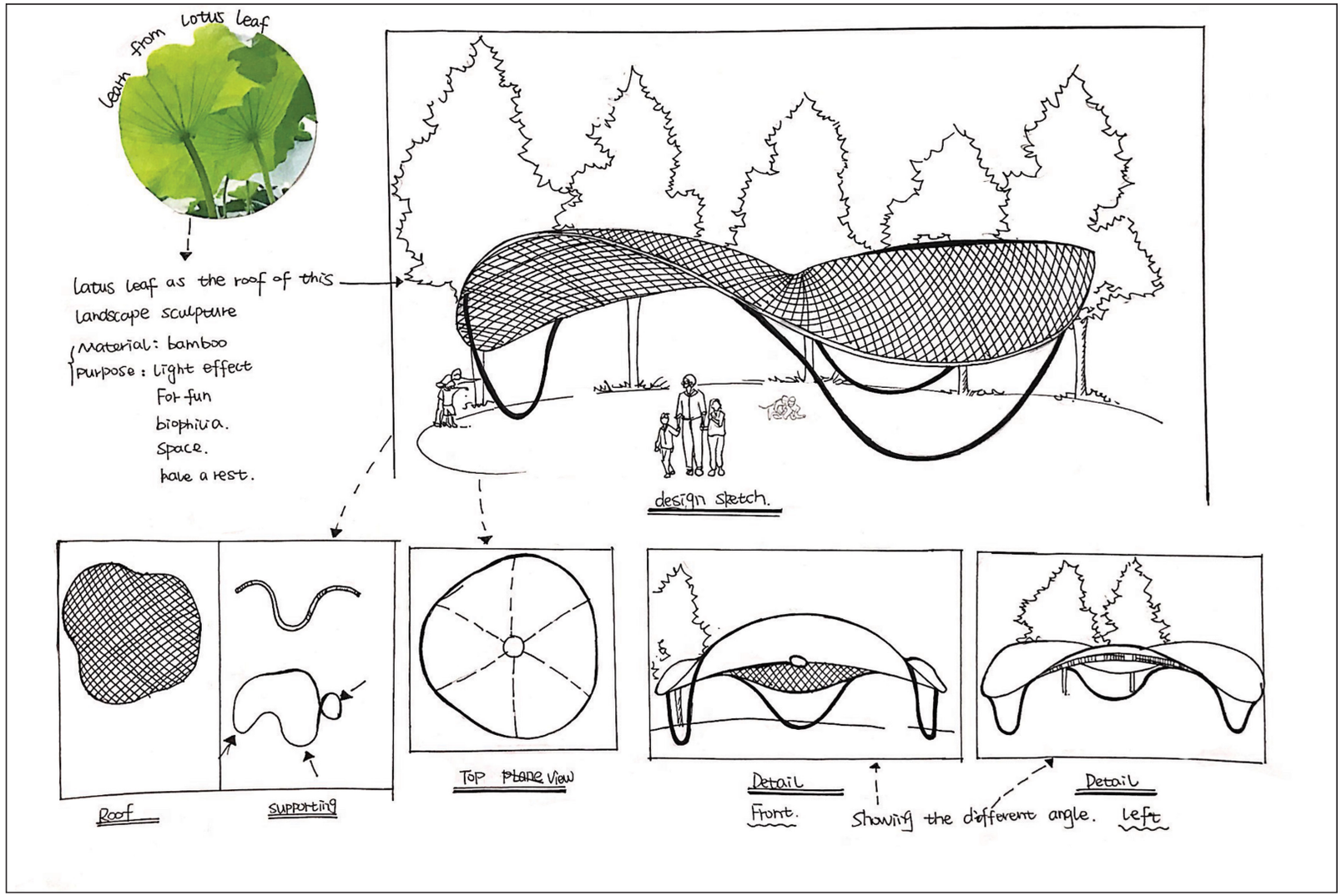
[Figure 19] Concept 4 inspired by mushroom,
sketched and illustrated by Gao (2018).



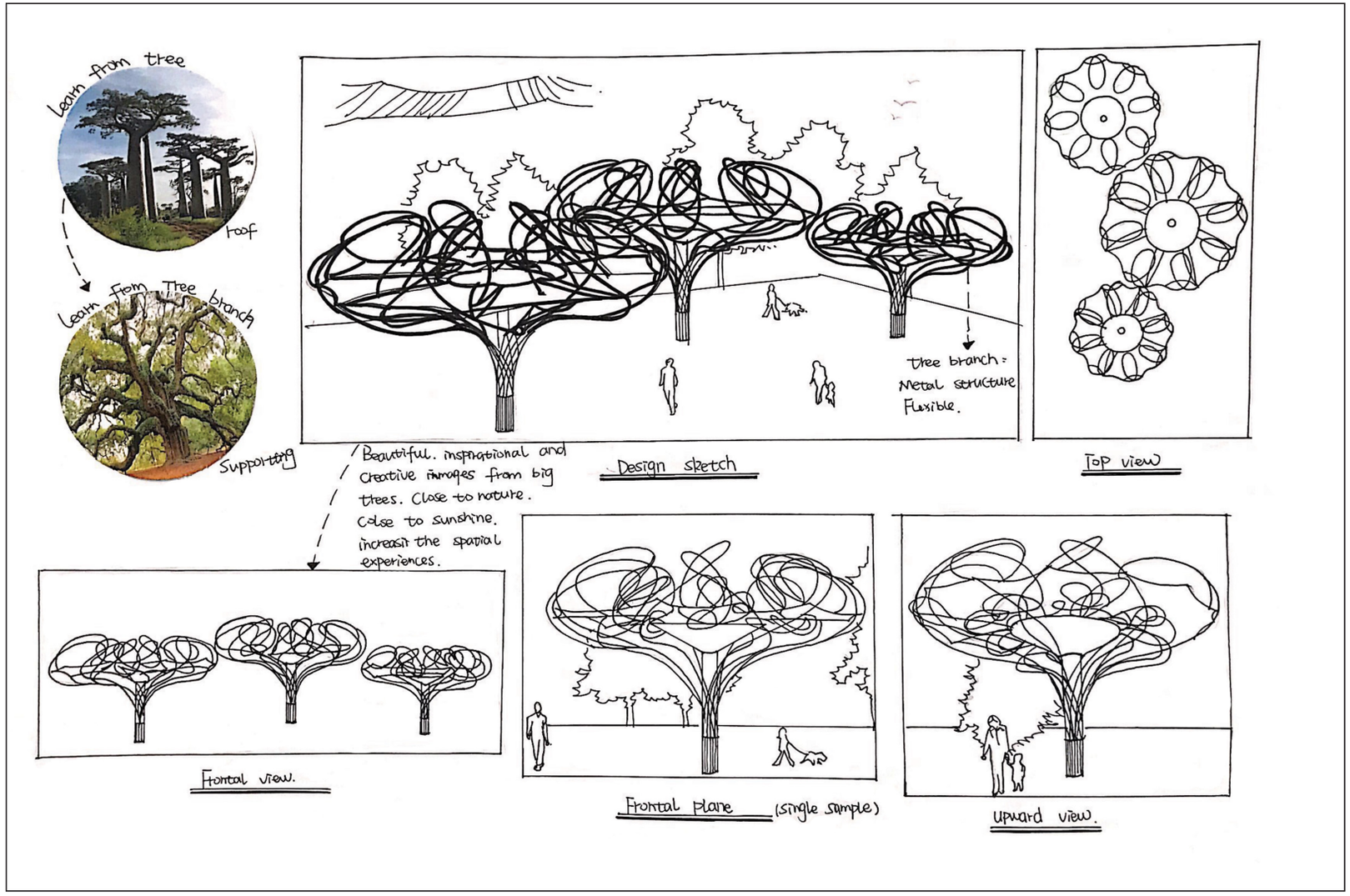
[Figure 20] Concept 5 inspired by the flower,
sketched and illustrated by Gao (2018).



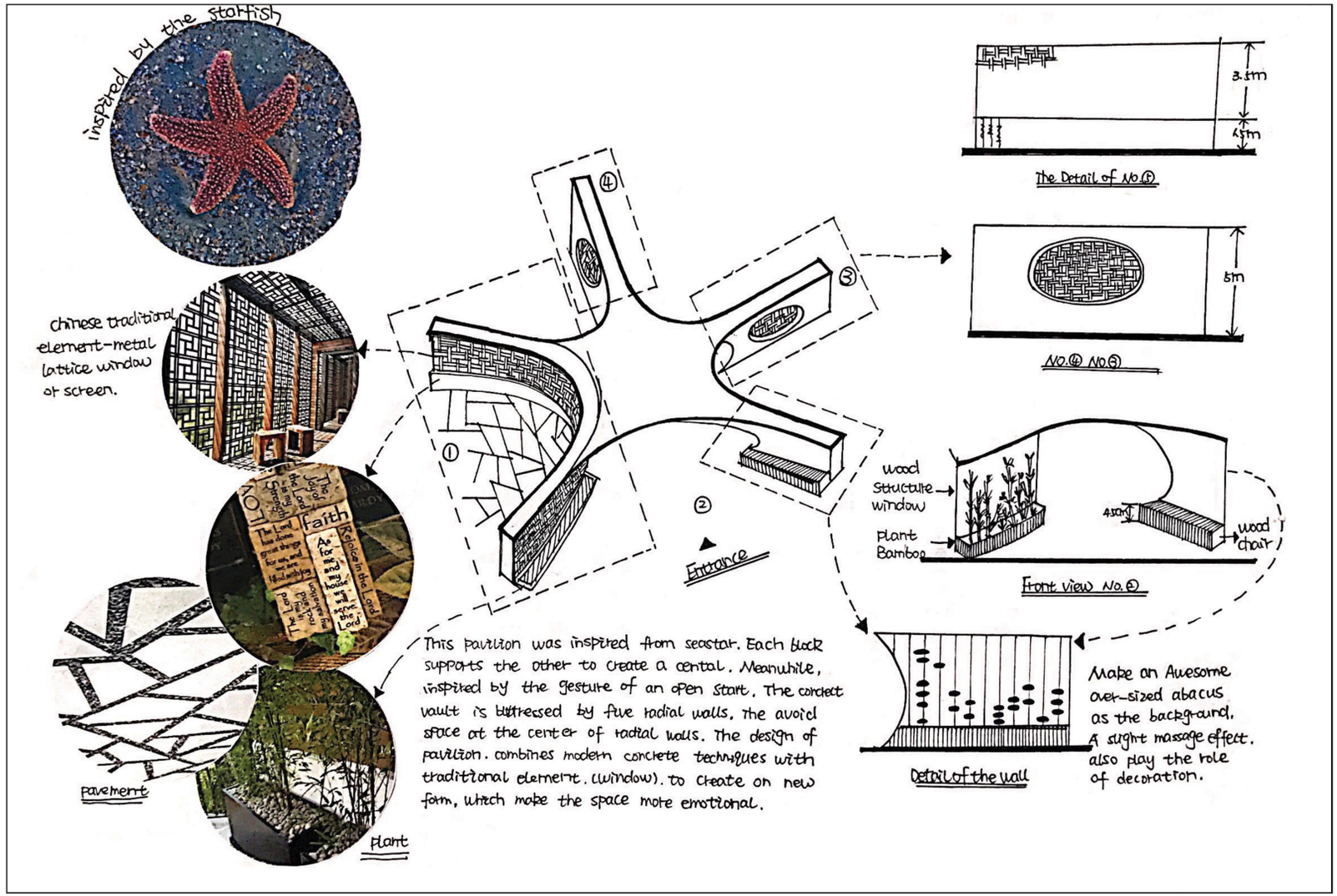
[Figure 21] Concept 6 inspired by the leaf,
sketched and illustrated by Gao (2018).



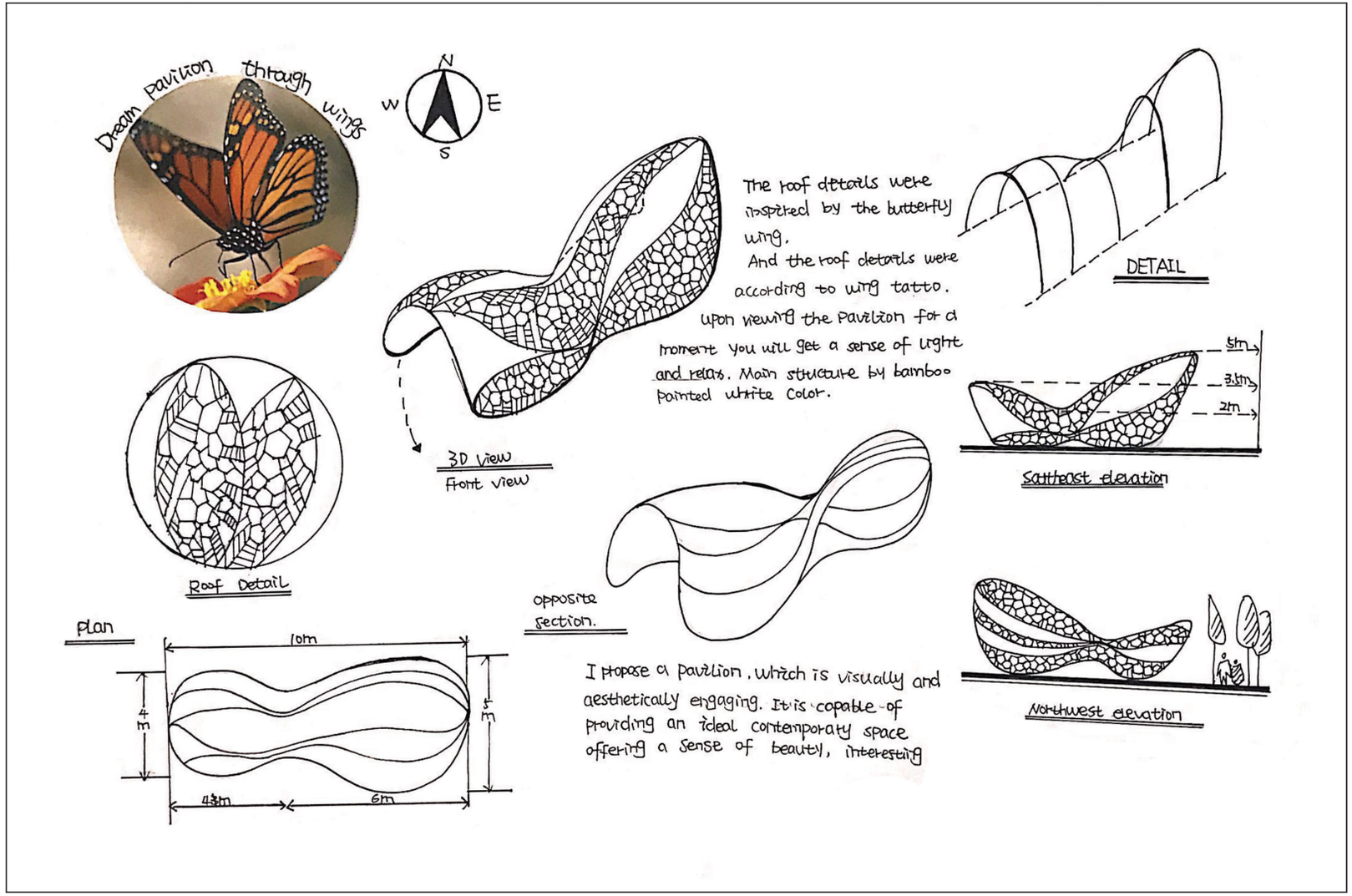
[Figure 22] Concept 7 inspired by a lotus leaf,
sketched and illustrated by Gao (2018).



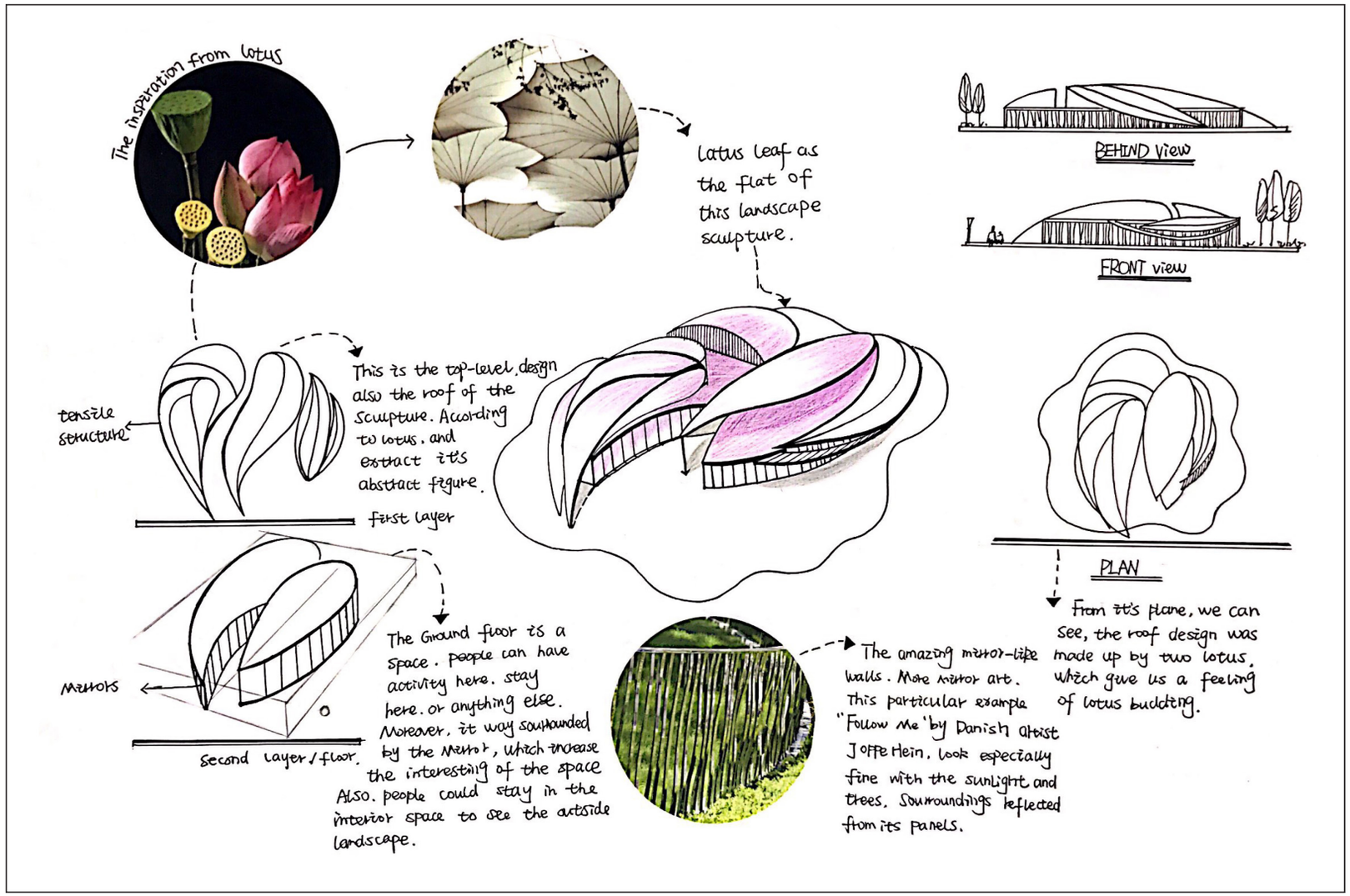
[Figure 23] Concept 8 inspired by the big tree,
sketched and illustrated by Gao (2018).



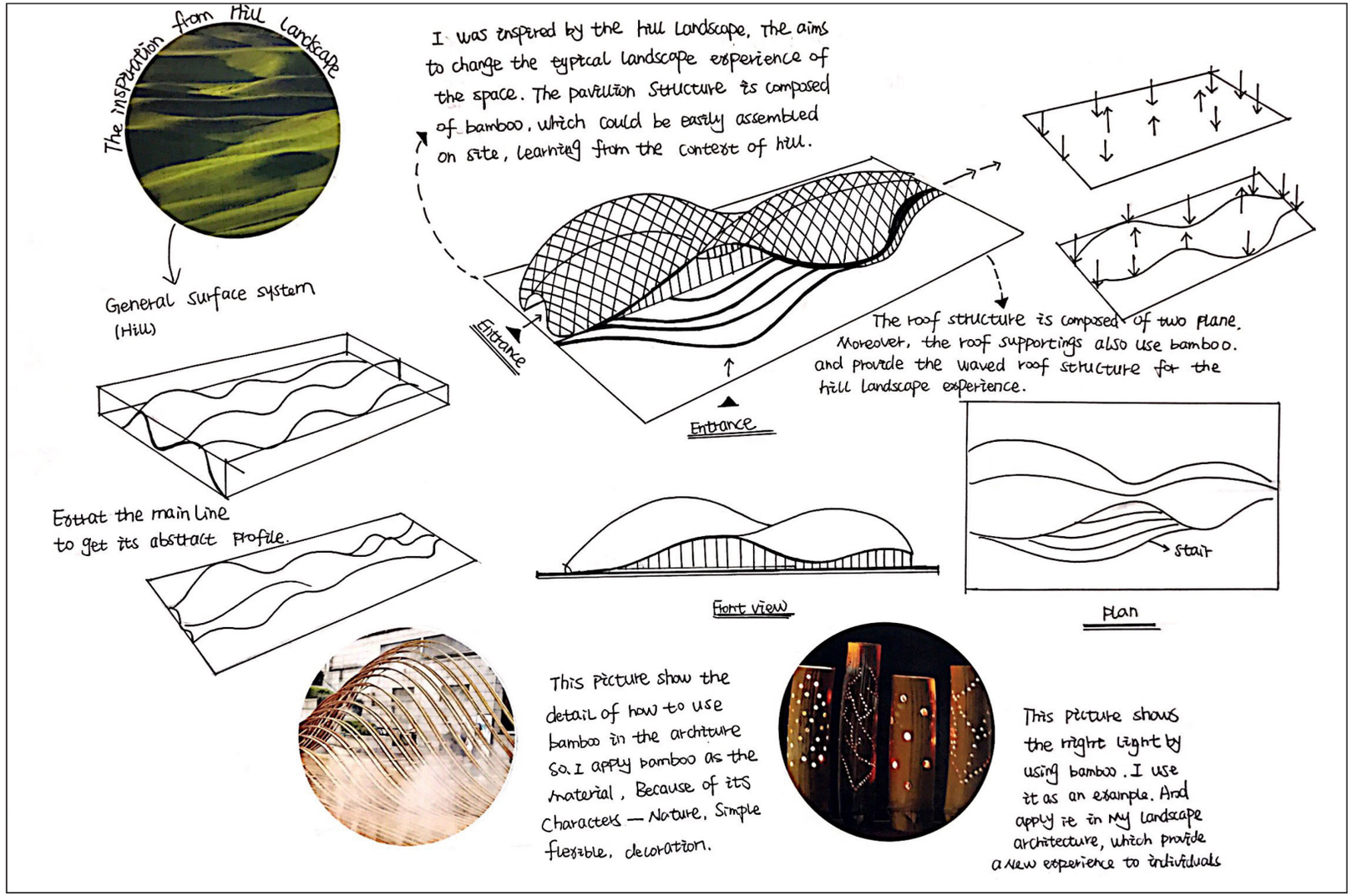
[Figure 24] Concept 9 inspired by the star fish,
sketched and illustrated by Gao (2018).



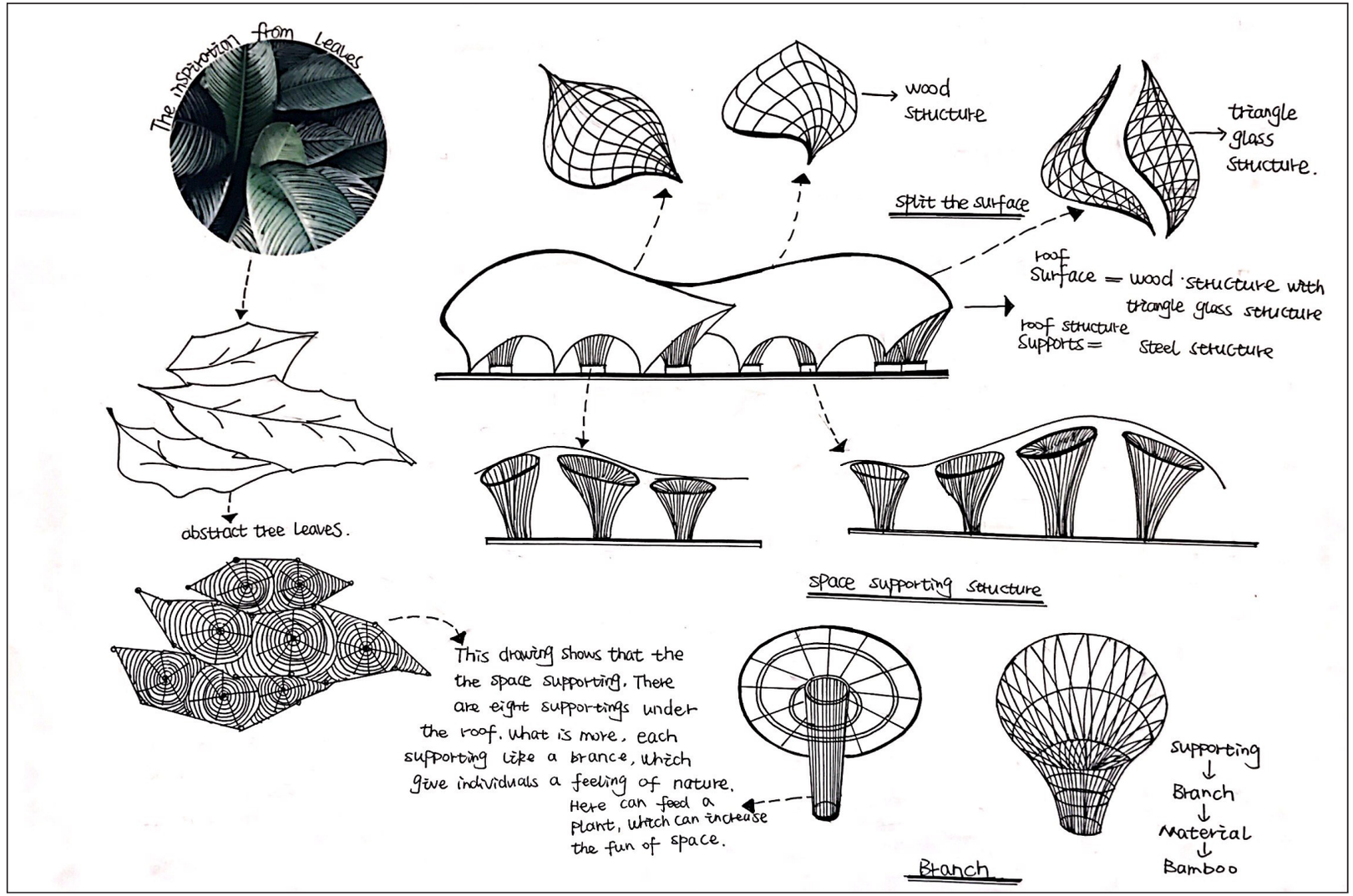
[Figure 25] Concept 10 inspired by butterfly wings,
sketched and illustrated by Gao (2018).



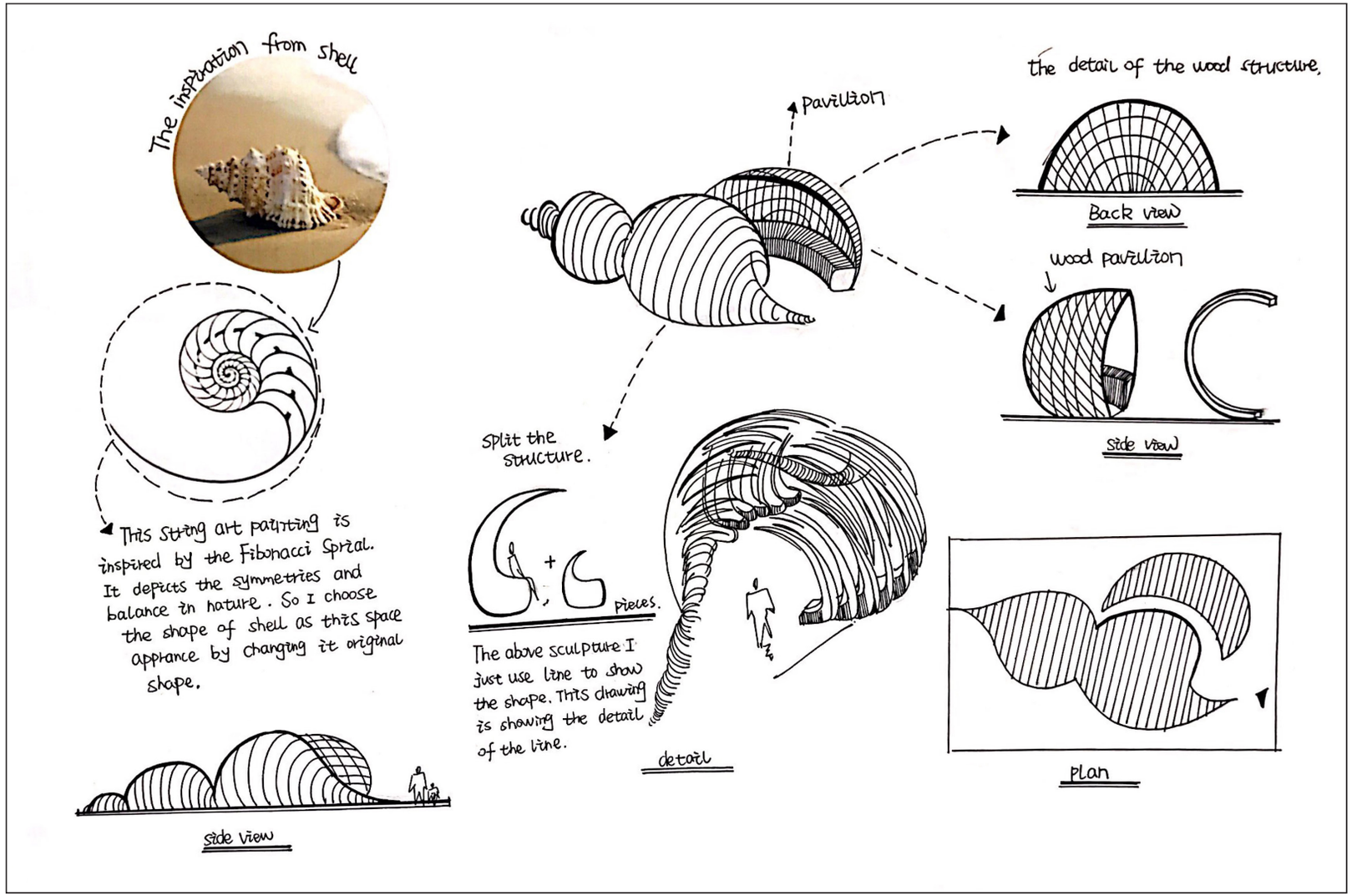
[Figure 26] Concept 11 inspired by lotus,
sketched and illustrated by Gao (2018).



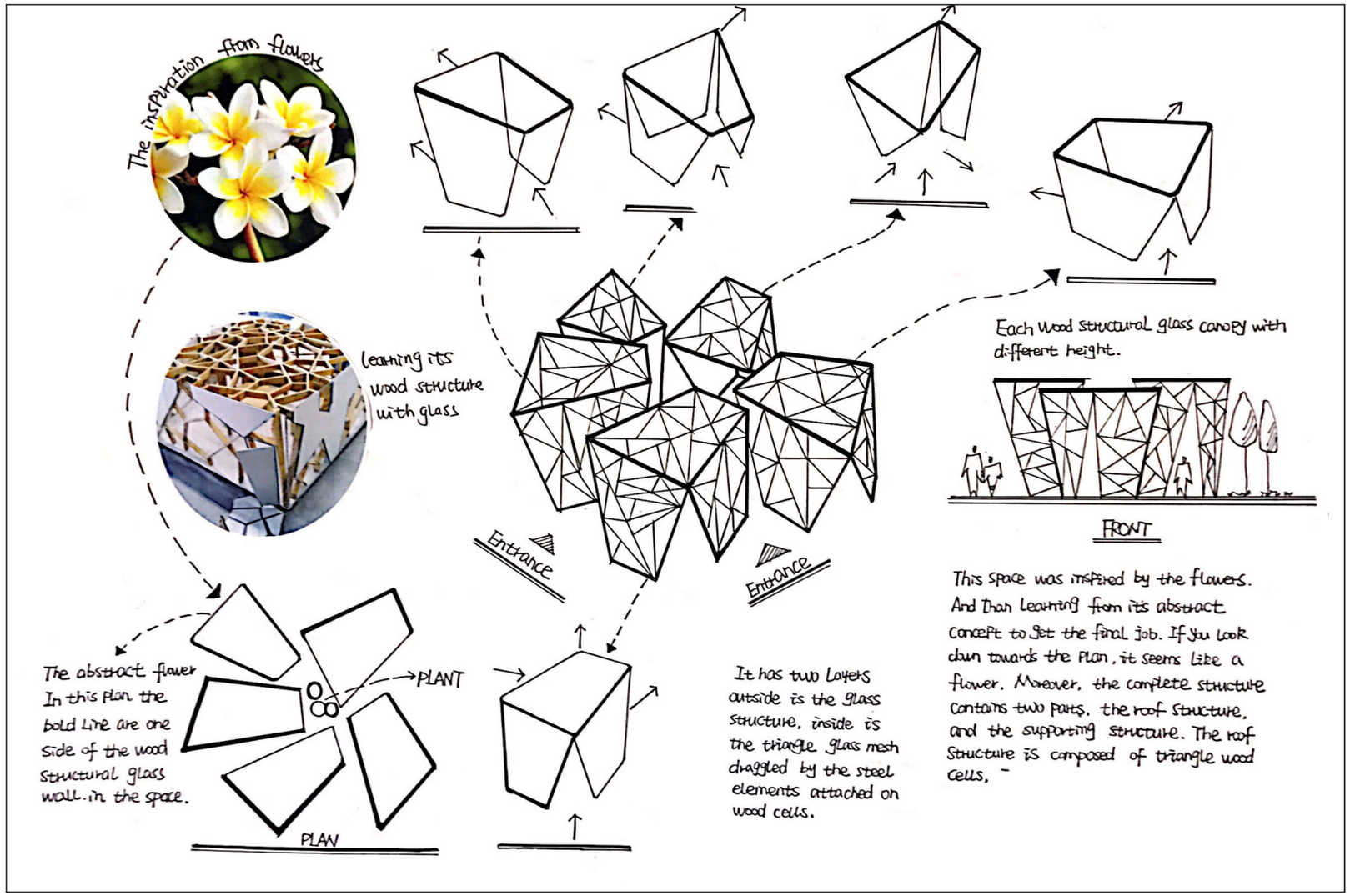
[Figure 27] Concept 12 inspired by hill landscape,
sketched and illustrated by Gao (2018)..



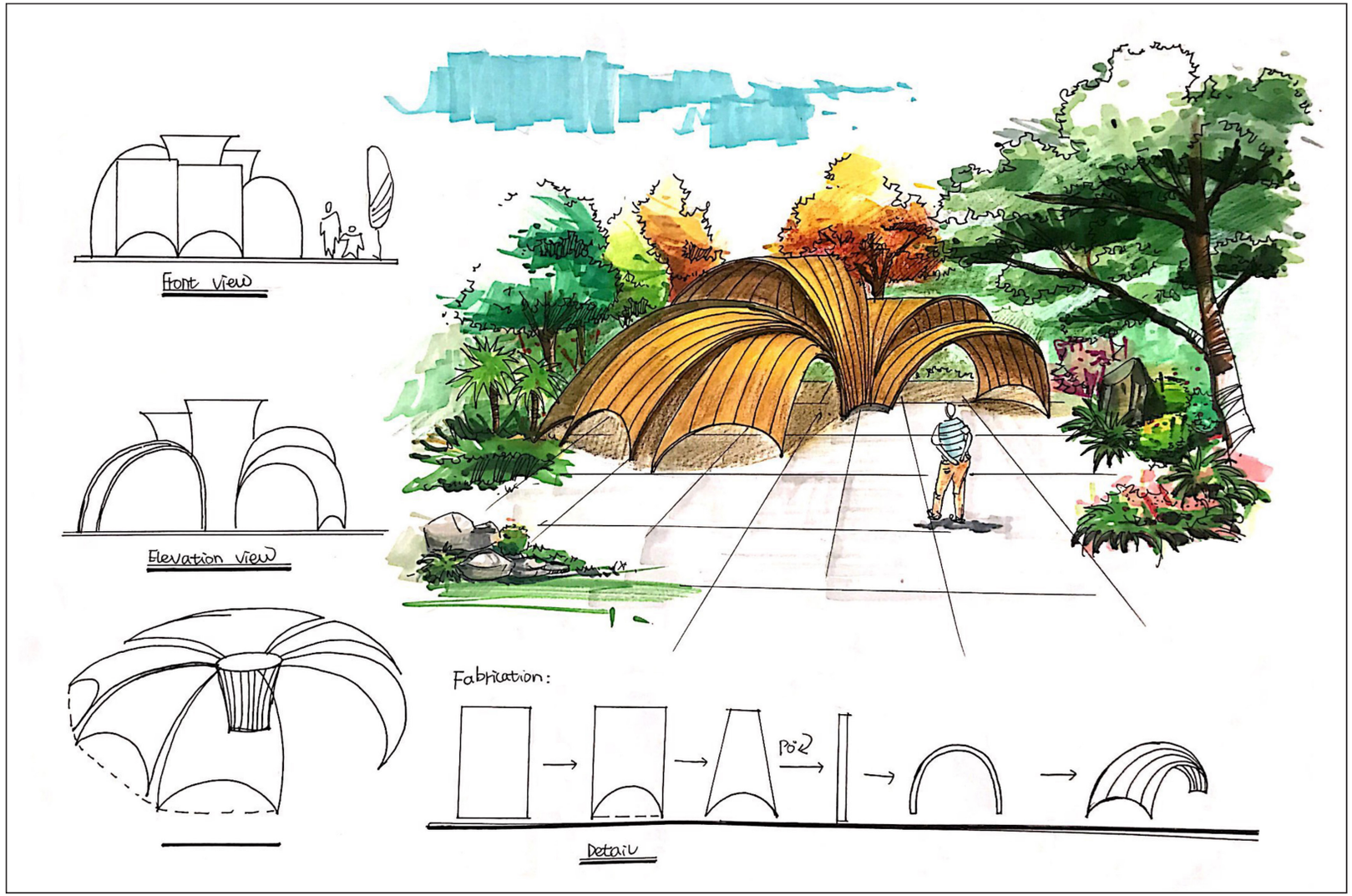
[Figure 28] Concept 13 inspired by the leaf, sketched and illustrated by Gao (2018).



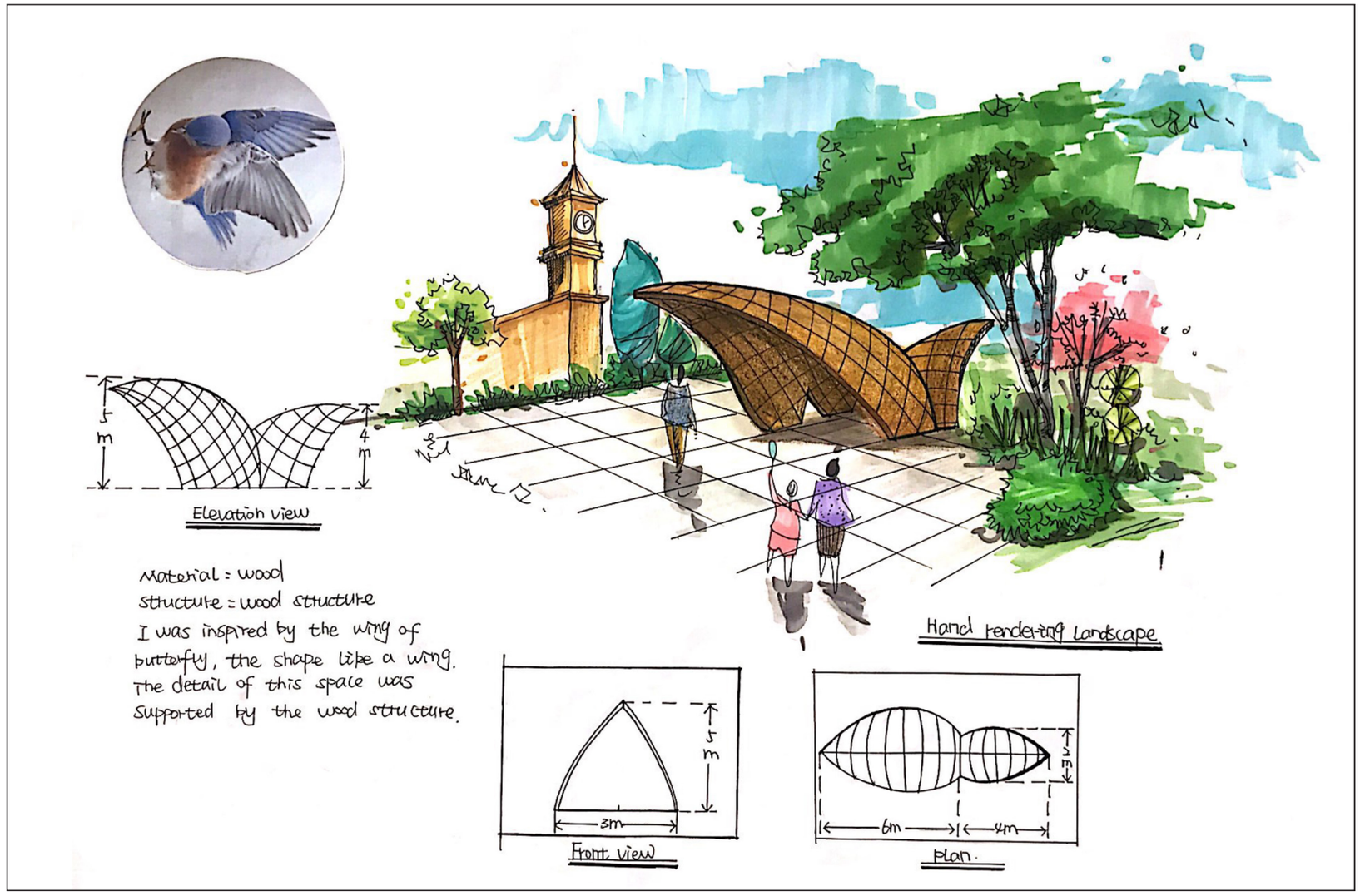
[Figure 29] Concept 14 inspired by the shell,
sketched and illustrated by Gao (2018).



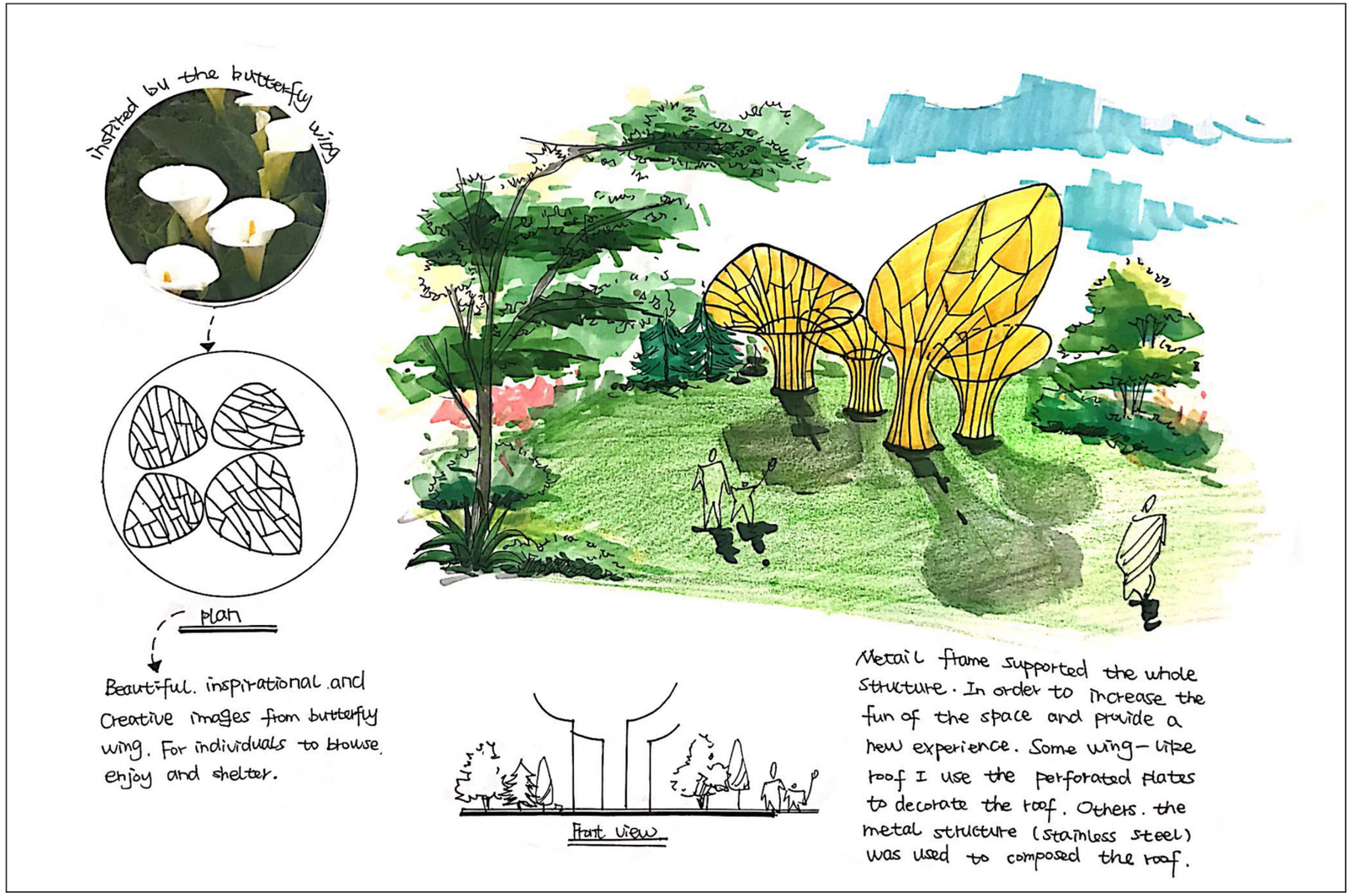
[Figure 30] Concept 15 inspired by the flower,
sketched and illustrated by Gao (2018).



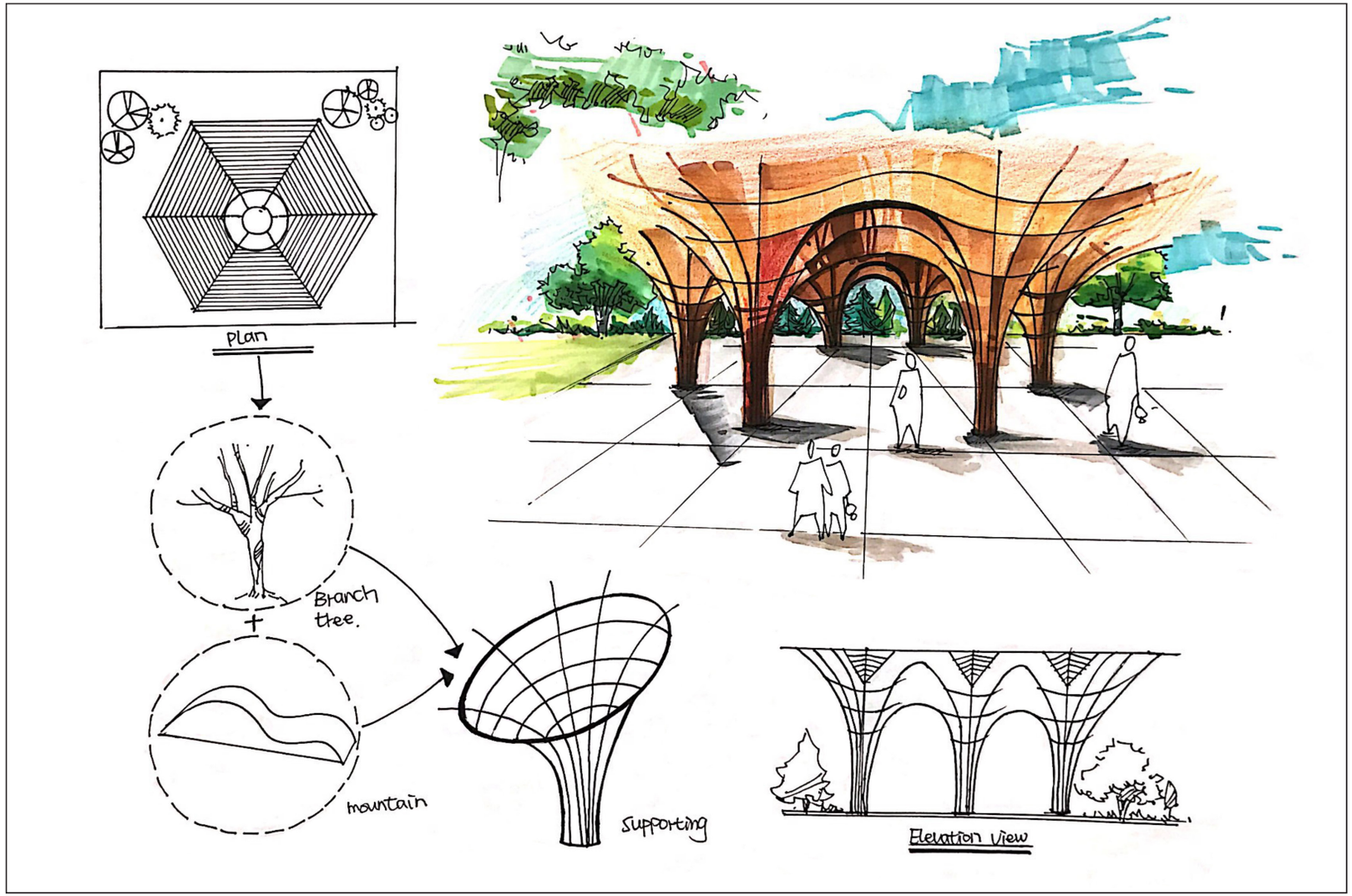
[Figure 31] Concept 16 inspired by the flower,
sketched and illustrated by Gao (2018).



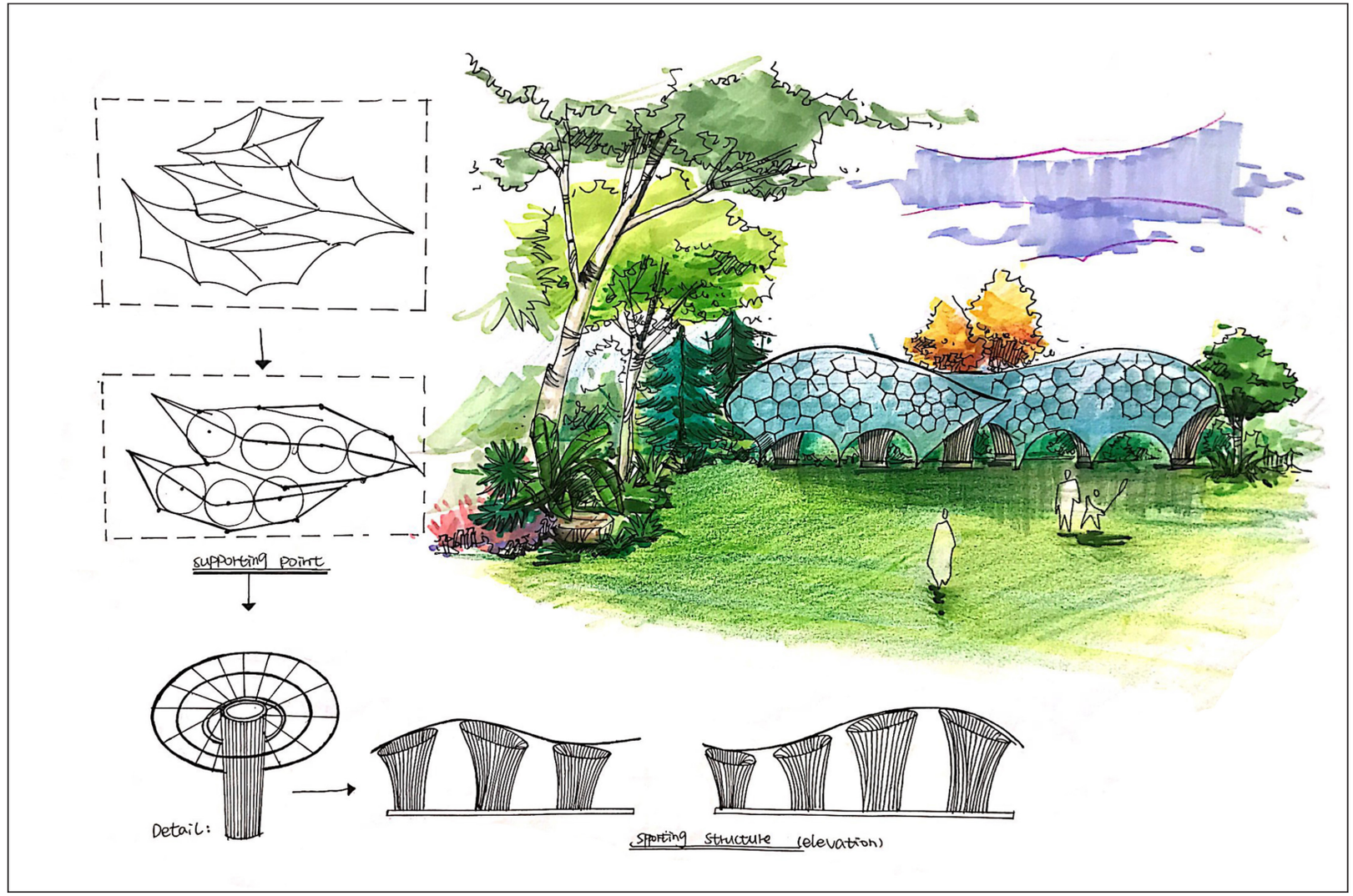
[Figure 32] Concept 17 inspired by the bird wing,
sketched and illustrated by Gao (2018).



[Figure 33] Concept 18 inspired by the flower,
sketched and illustrated by Gao (2018).



[Figure 34] Concept 19 inspired by the tree,
sketched and illustrated by Gao (2018).



[Figure 35] Concept 20 inspired by the leaf,
sketched and illustrated by Gao (2018).

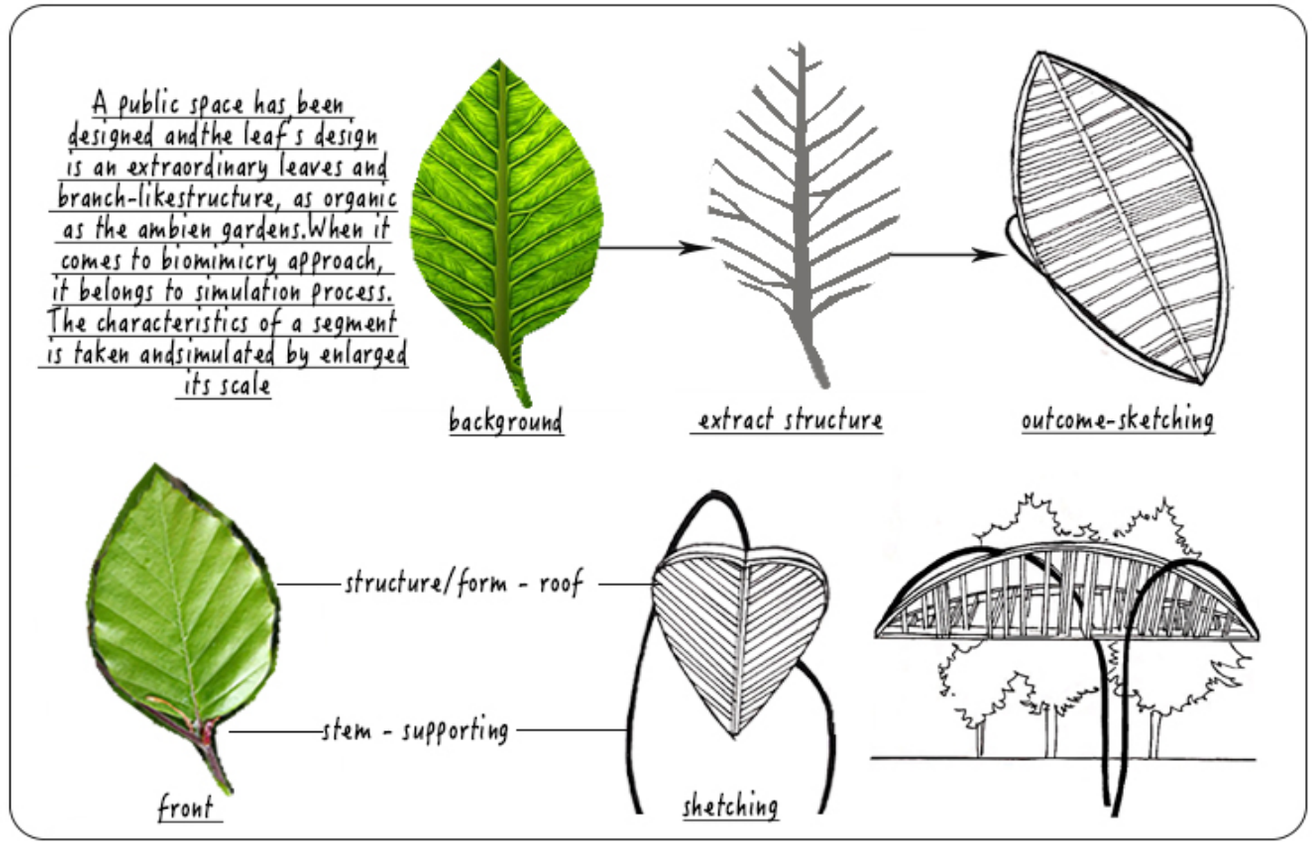
4.2 Design Development

The following proposed designs were developed from the previous concepts.
Detailed developments of pavilions are also presented

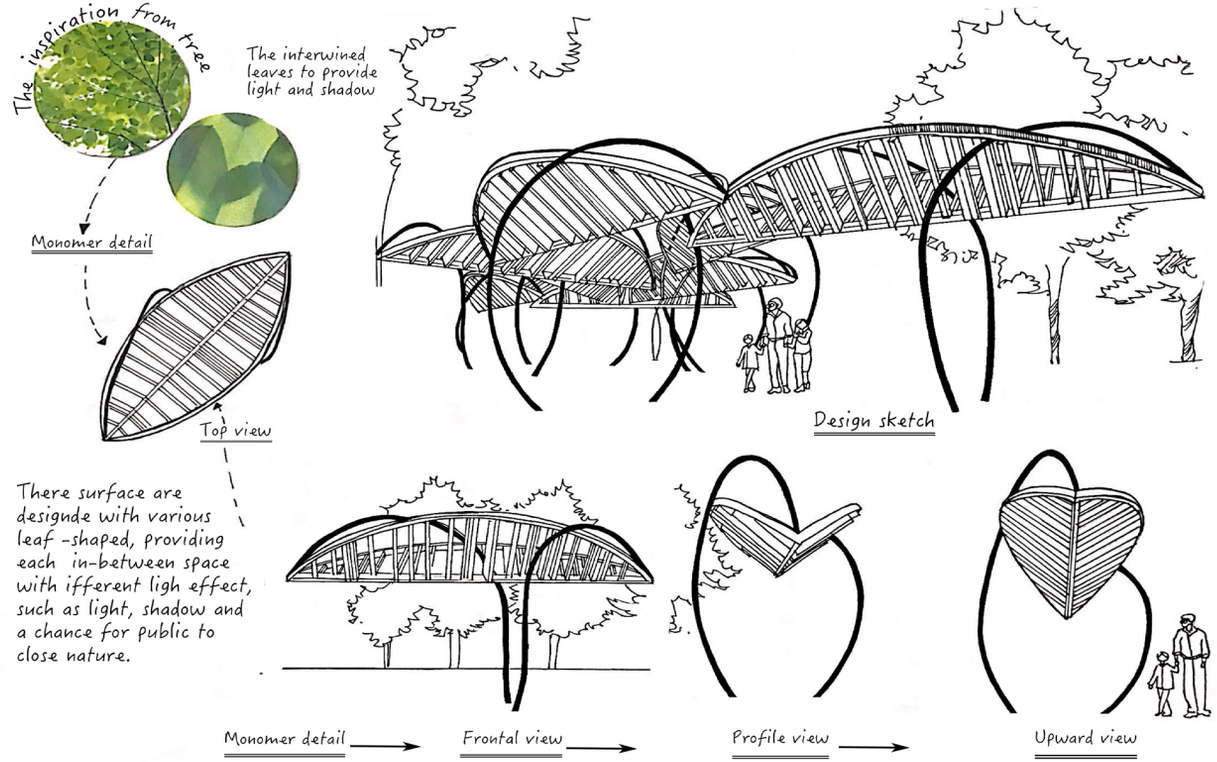
4.2.1 Leaf Pavilion

The following section on the Leaf Pavilion I will explain my thought process, and the various aspects of pavilion design, to render the picture and the connector of the pavilion.

4.2.1.1 Thinking Process



[Figure 36] Thinking process, free hand drawing, Gao (2018).



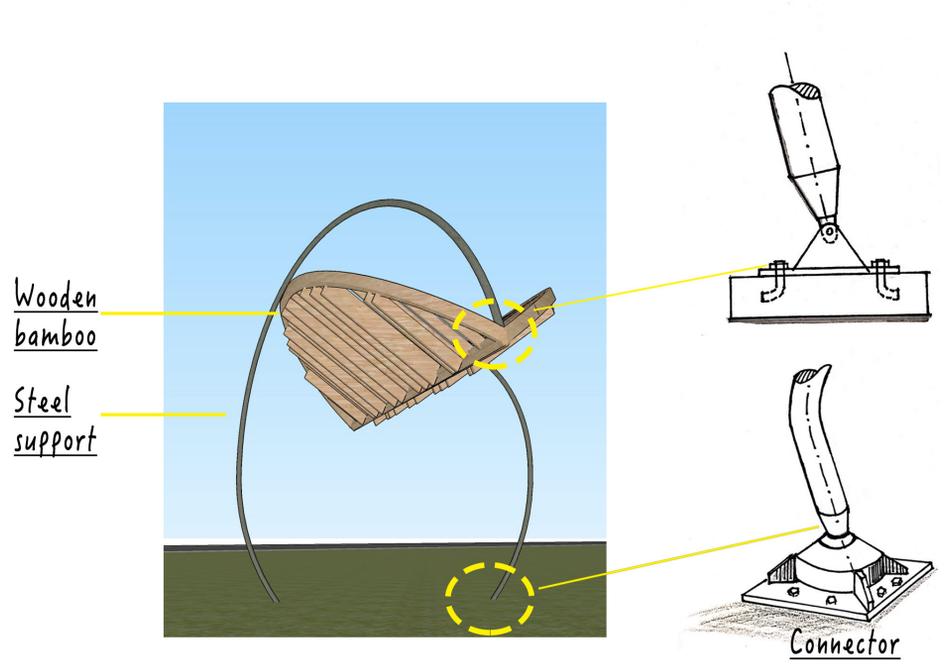
[Figure 37] Thinking process, free hand drawing, Gao (2018).

4.2.1.2 Material & Connector

Wooden Bamboo

Bamboo wood is used as a roof; it is lightweight, of high strength and has good stability, and has the advantage of being available in different shapes. It is a new bamboo product (Yu, 2017).

I propose to use bamboo wood as the primary material, and the data shows that this kind of material is straight, resilient, strong, and resistant to being moth-eaten; for these reasons, it is also called “steel bamboo.” Bamboo wood is for sure a green choice for environmental protection, and it does not need to be mined and subjected to a high-energy demanding manufacturing processes.



[Figure 38] Drawing showing the connector, sketched and illustrated by Gao (2018).

4.2.1.3 Design Specification & Visual Prototype

1) Simulation: copying the forms

The public space has been designed, using the leaf's design, as an extraordinary leaf and branch-like structure, as organic as ambient gardens. When it comes to the biomimicry approach, this work follows a simulation process. The characteristics of a segment are taken and simulated by enlarging its scale. Thus, this pavilion possesses biomorphic character. Furthermore, the architectural design connects with nature to feel part of the landscape, giving visitors a pure experience. I thought of ways to let the visitors experience the building by some simple elements, such as structure, module, shadow, light, color, materials, and forms. As shown (Fig. 39), this design is like a branch with luxuriant foliage that grows around it. The pavilion is fluid and enhanced by the interior space, I designed a thin, leaf roof which floats like duckweed on water in natural scenery. There are no walls for this pavilion design, but it was supported by two branch-like metal supports. The design has a visual preference for organic forms to help me to generate public spatial experiences. When people are walking in this space, they may describe the form of symbolic representation although our brain knows that the organism forms and patterns are not animate (Vessel, 2012). What is more, it could function as an interactive space where a person could stay temporarily in a beautiful landscape, and the relationship between the human being and nature could be entirely profound.

[Figure 39] Aerial view of leaf pavilion, Gao (2018).

2) Biophilia: (Table 2)

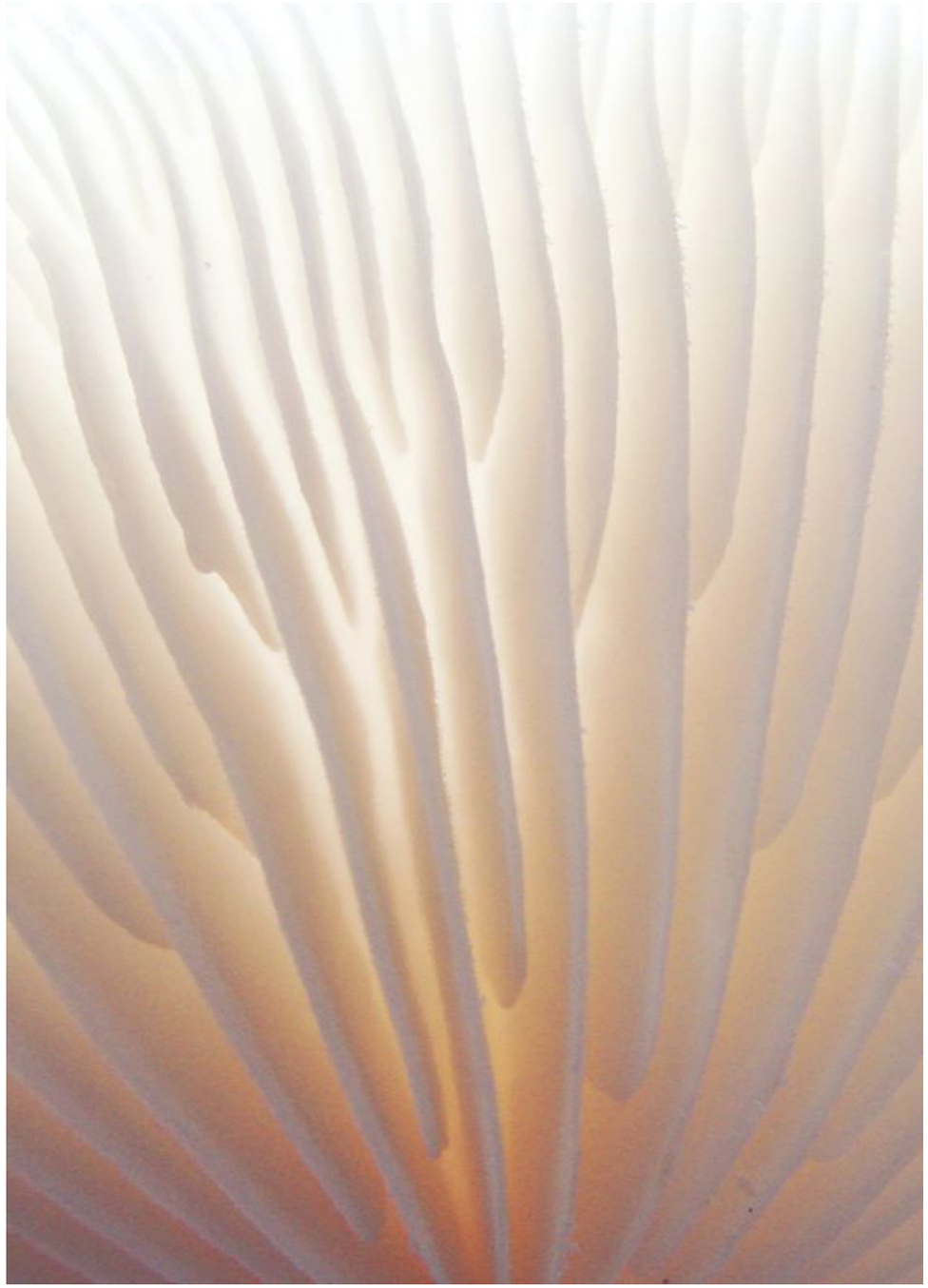
The visitor's spatial perspective is indeed their primary concern and a critical aspect for the pavilion. At the same time, I think visitors can sense that when they walk through the pavilion, the public can enjoy the shadow, light, materials, and order in addition to the organic shape. That is to say, I am looking forward to the public having contact with nature as they walk into the space. When light enters the interior through a chink in the architecture, no matter what time the sunrise or sunset, the light will change. All these buildings' shadows (Fig. 40) reflect upon the ground.

Even though space is a very abstract notion, a warm and relaxing spatial perception will be created. Meanwhile, an area with a good material connection will allow the public to feel close to nature and sometimes give the viewer an opportunity to touch it.

[Figure 40] Proposal site view, Gao (2018).

[Figure 41] Proposal site view, Gao (2018).

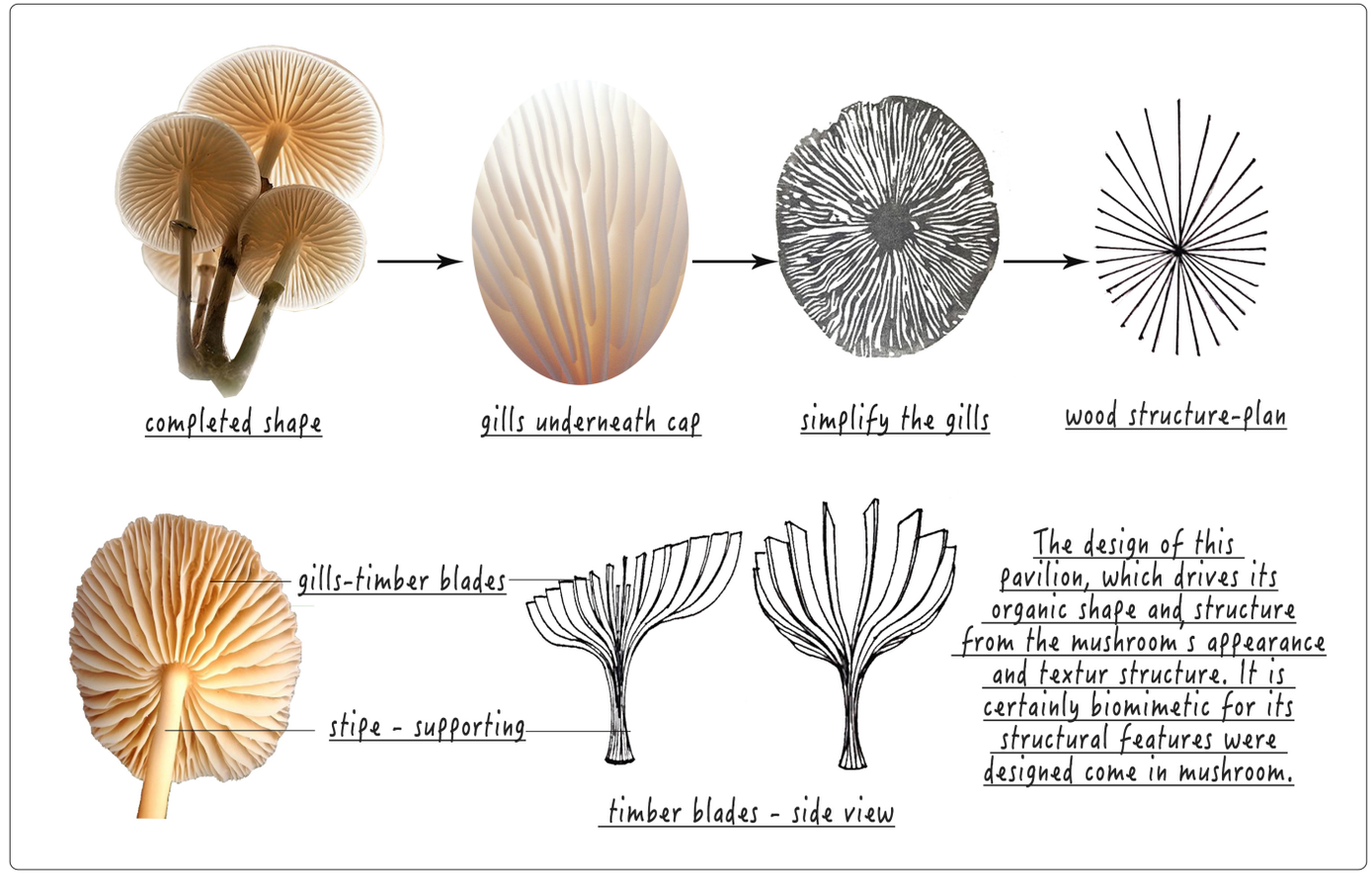
[Figure 42] Plan of leaf pavilion, Gao (2018).



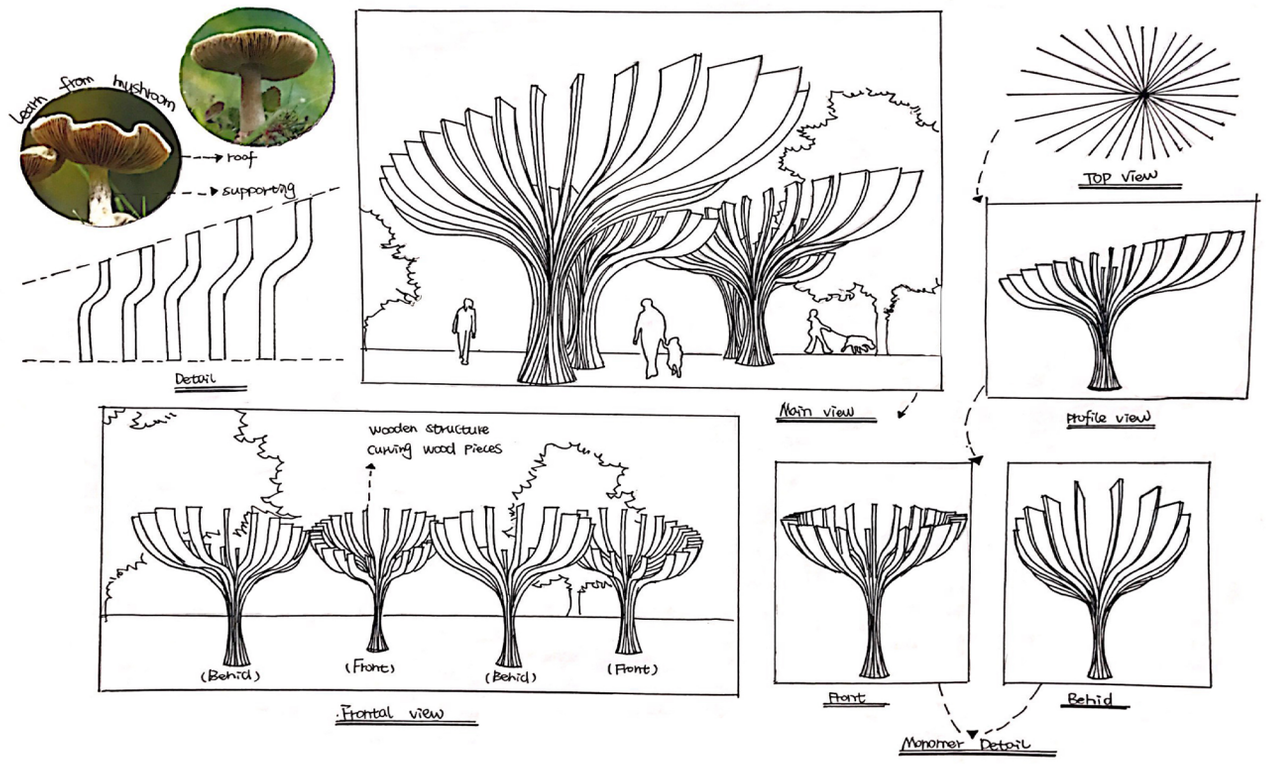
4.2.2 Mushroom Pavilion

In the following section on the Mushroom Pavilion, I will explain my thought process, and the aspects of pavilion design, to render the picture and the connector of the pavilion.

4.2.2.1 Thinking Process



[Figure 43] Thinking process, free hand drawing, Gao (2018).

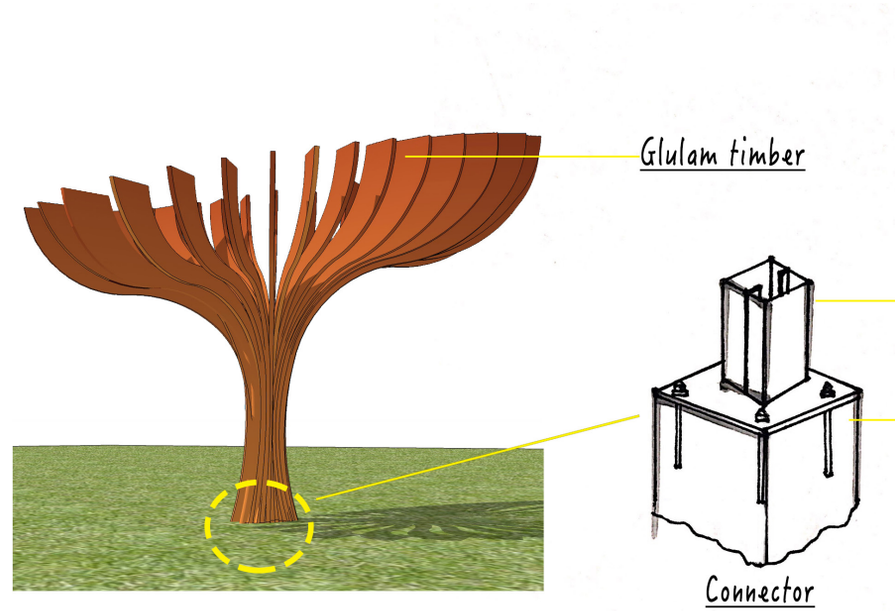


[Figure 44] Thinking process, free hand drawing, Gao (2018).

4.2.2.2 Material & Connector

Glulam Timber

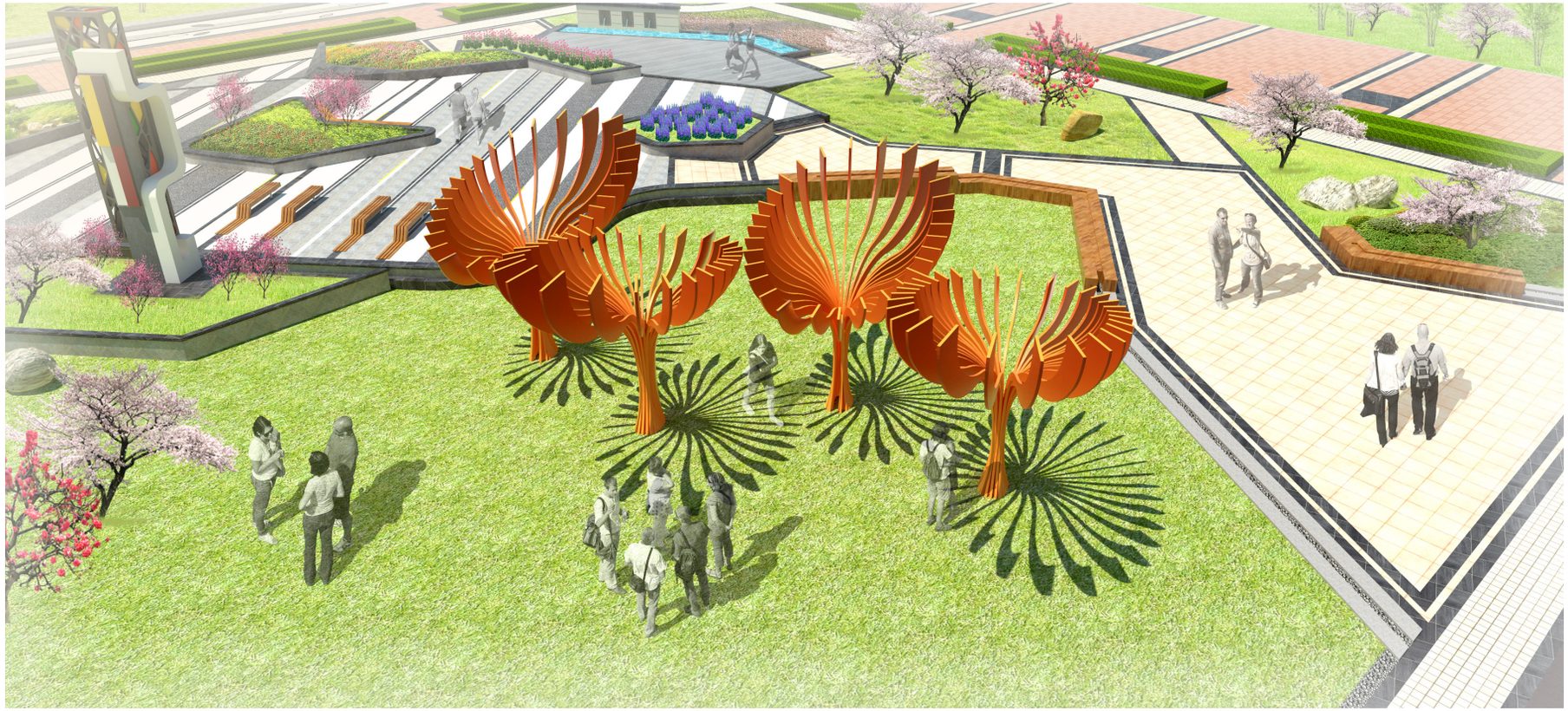
Compared with traditional timber construction, glulam is more flexible for design. In this project, it is used as the roof and support material because it is easy to shape a curved surface. In addition, there are types and exterior properties that mean it is able to fulfil multiple end-use requirements (Glued laminated timber, 2018).



[Figure 45] Drawing showing the connector, sketched and illustrated by Mengmeng (2018).

4.2.2.3 Design Specification & Visual Prototype

The design of this pavilion, which drives its organic shape and structure from the mushroom's appearance and textural structure. It is undoubtedly biomimetic, for its structural features were designed to be like a mushroom. I propose that with its giant wooden blades, I would like to create an important landmark that can be easily remembered by the visitor and create a clear identity of the area. In fact, the architectural object will be compelling because of its simplicity, being a mushroom-shaped pavilion surrounded by wood chips of different sizes. There exists a particular gap between each part of the wood chips. This design is derived from the top of a stalk of fleshy fungus. Also, the supporting part was inspired by the stem, like the structure of a mushroom cap supported by its stem. On the one hand, this mimic the organic shape of a plant, dramatically increasing interest in the design. On the other hand, it is a space that people could explore; I think the idea from the mushroom is to provide a space that people will take the time to walk around, where the public could enter from different points. I also suppose that the pavilion is a favorite space for visitors because of how lively and visual it is.



[Figure 46] Aerial view of mushroom pavilion, Gao (2018).

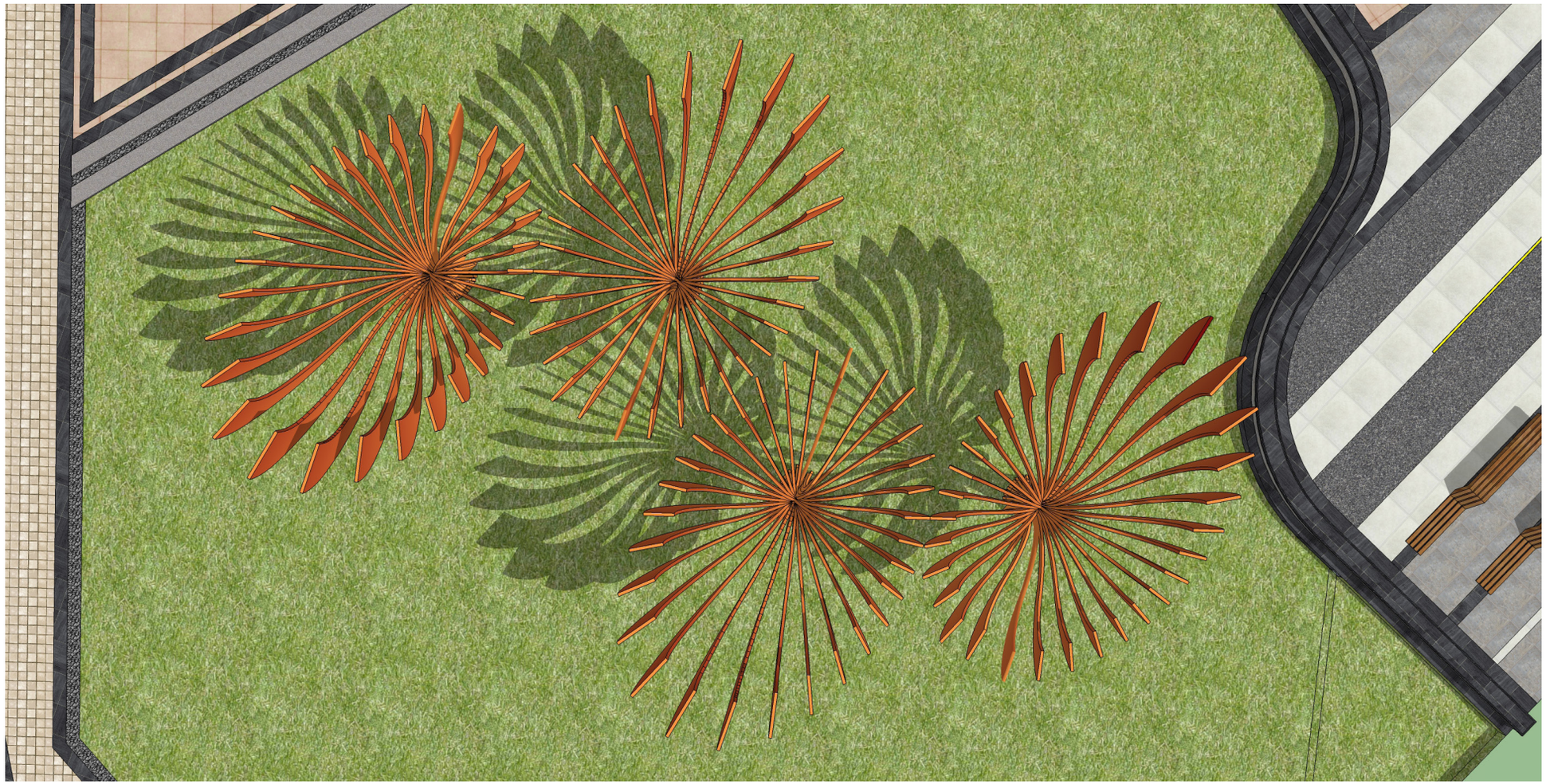
In my learning from various patterns of biophilia, such as light, shadows, complicated order, and natural material, the designs have offered me enthusiasm for my pavilion. The entire space is arranged as a continuous interstice with four staggered mushroom-shape buildings. This kind of arrangement of pavilion form, vault and pathway that will allow people to have more interaction in this space.

[Figure 47] Proposal site view, Gao (2018).

From the vertical view, the arrangement of continuous surfaces and these winding vertical surfaces allows the appearance of the architecture to live in harmony with the surrounding environment. At the same time, the pavilion's spatial experience is intended to provide viewers with a three-dimensional "multi-layered" architectural experience, which reminds visitors both of the mushrooms on the exterior and then illustrating the outside natural light shining into the building through the gaps once they enter the building.

The purpose of the material connection with nature in this design is to allow the visitor to discover the natural materials' features and quantities to generate active cognitive or physiological responses. A study indicated that various physiological reactions would be engendered because of differences in the wood proportion on the wall of the interior (Tsunetsugu, Miyazaki & Sato, 2007). The investigators observed a room with a reasonable percentage of timber (i.e., 45% coverage) is sure to have a subjective sense of comfort. Being influenced by the pattern of material connected with nature, I proposed a type of structural timber product "glulam" as the primary material, as noted above. A space with an element in its natural state creates a sense of warmth, is authentic and stimulates individuals to want to touch it.

[Figure 48] Proposal site view, Gao (2018).



[Figure 49] Plan of mushroom pavilion, Gao (2018).

5.0
Significant
Finding

5.1Four Pleasure of Making a Meaningful Experience

Jarvis (1987) discusses experience happening in a social-cultural-temporal environment where there is no meaning to the situation itself. However, the experience might have meaning if people make sense of experiencing it. For example, the experience became a story or turn it into a pleasant memory; only that kind of experience could be viewed as a meaningful experience.

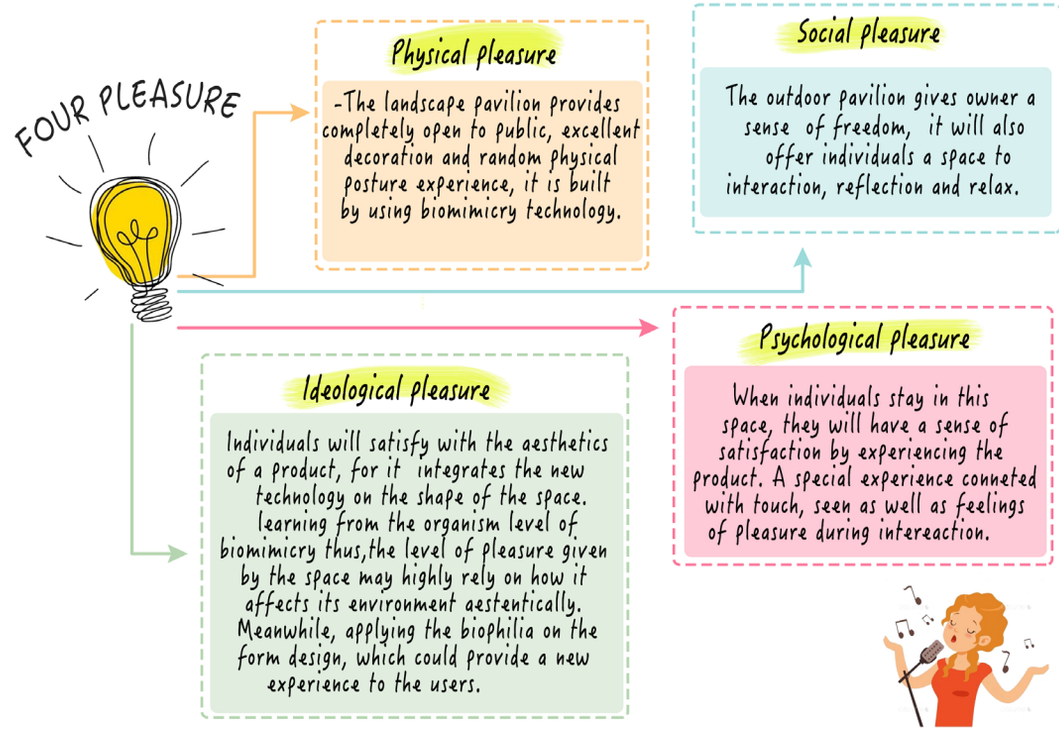
The experience of both space and place for the human is a perplexing social phenomenon, which includes geography and perception, as well as more social and personal interaction space (Lentini & Decortis, 2010). Furthermore, Jordan (2002) indicated that if a meaningful excitement was expected to be created, a good experience design should possess balance among the four pleasures (ideological, physical, social and psychological comfort).

As mentioned before, there is no meaning for the experience in a situation; only if it was changed into a memory or a story are the results of the background meaningful. So, what kind of significant experience do people desire? Diller, Shedroff, and Rhea (2005) researched the meanings people find in their experiences, and made a list of 15 types of meaningful experience (Table 3).

Accomplishment	Enlightenment	Redemption
Beauty	Freedom	Security
Community	Harmony	Truth
Creation	Justice	Validation
Duty	Openness	Wonder

[Table 3] Shedroff et al (2010) 15-core meaning experience.

In the future, a product can capture this core meaning to create a meaningful experience for the public; the following figure illustrates the four pleasures in relation my open space, which I explain according to the 15 types of meaningful experience.



[Figure 50] Four pleasure illustrated by Gao (2018).

6.0
Discussion

Previously in the present report, I have considered biophilia and biomimicry in connection to landscape architecture. The study aimed to apply these two concepts in a building to ask what kind of spatial experience is sensible for users, in order to get a more comprehensive understanding how biomimicry and biophilia might psychologically affect users' perceptions of and physiological responses toward architecture design. Because there are many studies concerned with the same application, they help with understanding the outcomes of this research. Therefore, some points of discussion can be drawn from the review.

There exist overlapping insights regarding mimicking the natural form, for example, in the Landesgartenschau Exhibition Hall mentioned before. This might indicate that using biomimicry and biophilia in the physical structure not only focusses on the building itself but also on a sensory experience in the users' mind through vision, touch and so on.

6.1 Discussion from the Biophilia Aspect

6.1.1 The Material Application

Biophilia could be manifested as a desire to have natural elements, such as wood, in our surroundings (Kellert, 2005; Kellert et al., 2008). This is because biophilia can provide indications for potential psychological benefits of such natural elements for human beings, So, I would like to apply a natural material to build my pavilion. This material can be a type of timber. So, why might interior and exterior wood be psychologically beneficial? Why do people recover from stress and ill health by merely having visual access to nature? In the following section, I will offer a brief introduction to some theoretical viewpoints.

(1) Visual perception of wood

The visual impressions of timber can differ because of some factors, such as species, knots, color, structure, and surface treatment. Investigating the visual perception of wood can provide us with further insight into how different properties of wood are perceived by humans.

Consider, for example, color. Interior spaces containing substantial proportions of wood are often described as “warm” and “natural” (Rametsteiner Oberwimmer, & Gschwandtl, 2007). Masuda (2004) hypothesized that people might receive a sense of warmth and naturalness from wood because of its color and hue. To be more specific, owing to the reflection of timber being long-wavelength light and the low reflectance of UV light from a wood surface, people may experience a warm impression and less stimulation, and consequently this may defeat fatigue.

(2) The tactile sensation of wood

By analyzing what they see, people can obtain a comprehensive knowledge of the physical environment. Therefore, past visual experiences of nature are the leading forms of research regarding human responsibility toward nature. However, timber in architectural applications also has some physical characteristics. When using wood in the architectural environment, there are plenty of opportunities for people to touch miscellaneous wooden materials, such as wooden building materials and a wooden roof. Consequently, people could gain from the experience about the physical environment by a sense of touch. However, I initially planned to use timber as the material for the whole architecture.

Finally, my design ended up with wood material only for one pavilion, the Mushroom Pavilion. The reason why I changed my idea for another building is that when considering the bearings and supports, I found that it is difficult to bear the weight when I use timber for the roof and support for the Leaf Pavilion. So, I developed bamboo wood in place of timber. As noted previously, it is a new natural material which possesses features of being strong, resilient, straight and is resistant to being moth-eaten.

6.1.2 The Experience-Working with the Pattern

Biophilia lays out a series of patterns, and these patterns provide a set of useful tools for understanding design opportunities so that individuals and society might enhance their health and well-being in our design applications. In analyzing my design, I would like to discuss some inspired patterns from “14 patterns of biophilic design” (Table 2), as follows:

• Pattern 6: Dynamic and diffuse light use different intensities of light and shadow that will change over time. Space is in view of light and shadow, which show time gradually, and a sense of calm will be revealed.

• Pattern 8: Biomorphic forms and patterns indicate time references used to depict contours,patterns and textures that persist in nature. A space with these characteristics will be comfortable, probably engaging, and thoughtful.

• Pattern 9: The material connection with nature is material coming from nature, which could create a unique feeling of place. Learning from this feature, the space will have a good connection with nature and allow people to feel warm and enjoy nature.

• Pattern 10: Complexity and order is the abundant information of sensory feelings that persist in pursuit of hierarchical spaces resembling those occurring in nature. A complex and ordered space experience is meant to feel like a rich space, which often plays an important role in adjusting the boredom of a space.

6.2 Discussion from the Biomimicry Aspect

This research applies biomimicry as a practical approach to make design visualization and to evaluate the potential for architectural experience. Introducing the physical and mental response is intended to capture the effective component of the architectural experience stimulated by this visual design. A visualization study on biomimicry makes great sense to assess the experimental aspects of architectural space. Usually, designers and architects were looking for inspiration from biology to solve human problems; they not only mimic the forms of animals and plants but also find design methods similar to the growth and evolution of nature. A perfect example of animal architecture is the Africa termite mound; it provides a solution to a design problem in architectural design, such as ventilation, humidity control and strength of the structure. The Eastgate building in Harare, Zimbabwe, was a great success in mimicking the ventilation system of the Africa termite mound. This key to the biomimicry approach might focus on its function, which is used to solve a human problem. However, for my design, I am focusing on getting inspiration from plants and animals to design my pavilion. By coping with the appearance of the structure or form from nature and then enlarging its scale of form, these designs were not looking forward to any effective work as nature does, but were expecting to pursue natural forms influencing the design. Therefore, for me, I consider biomimicry as a useful application that will help with relationships to design a space for public space perception. Also, it is the primary source of inspiration for architectural aesthetic expression.

6.3 Discussion of the Site Selection

When considering the development of the project, a real site should be provided for the pavilion. The critical dimension of the research is to create a spatial perspective for the public by applying biomimicry, for the approach belongs to the simulation process of biomimicry, as I am focusing on learning the organic shape from nature. Thereby, the selected reference object for site selection is urban open space, such as an urban park or open square. Public space should be regarded as temporary space, where people are refreshed, and experience the urban environment. Most people live in the urban environment, and more people expect to reside in the green residential environment. So, the urban park offers the public a chance to be close to nature. In land use planning, the urban open space, such as "public parks," and "green spaces" are open and free for the public ("Urban Open Space" 2017). Additionally, as well as bringing people closer to nature, public parks are described as places for "stranger meeting" (In fact, some people argue that there are few places where people engage with others despite their different background and financial situation (Thompson, 1998)). A public park makes a possibility for an intimate time or space as well as a way of recovering our inner peace (Thompson, 2002).

Through the above analysis, there are some public open spaces which can be considered as potential sites in Auckland, such as Albert Park, Victoria Park, and Myers Park. The possibility is because those places allow people to regain their busy life and increase a sense of belonging. Meanwhile, in comparison with modern buildings, a natural space helps my design to provide a better spatial experience for visitors.

7.0
Conclusion

The purpose of the pavilion is to study the structure of landscape architecture as a place for expressing freedom and spatial perception. At the same time, by exploring how bio-technology inspires me when it is applied to architecture and morphed into a new shape, so the critical aspect for me is to explore and find the relationship among landscape architecture, nature and spatial perception, as well as using this knowledge to stimulate my pavilion design. In the past, most traditional pavilions may have started with a conventional architectural feature, and a traditional pavilion is mainly built for scholars to recite poems and enjoy drinking. However, I am fascinated by how this artificial landscape architecture offers a new way for people in the city to experience nature. For modern architecture, natural factors (such as structure, texture, color, forms) are introduced into architectural design due to a desire to emphasize space experience. To create a more spatial perception, biomimicry has been one of my useful references for study. Frequently, biomimicry as a design process method has been split into five types and three levels. The five types are simulation, interpretation, integration, replication, and emulation; the three levels are the organic, behavior and ecosystem levels. Some designers use biomimicry as an approach to deal with their design problems.

Meanwhile, biomimicry can be regarded as the source of innovation in the field of science. Scientists not only mimic forms from biology but find solutions resembling nature. For my design, the key to the biomimicry approach might focus on its organic level which uses appearance design. By duplicating the exterior of the structure or form from nature and then enriching its dimensions, these designs were not aimed at any tough task as nature is, but the desire to be in pursuit of natural forms influencing design. I consider that biomimicry works as a helpful application that will end up with a good result in designing a space for spatial experience. It is the fundamental source of inspiration for the aesthetic expression of architecture as well. It is because biophilia can provide indications for potential psychological benefits for human beings that biophilic design is set to become an essential part of human life which emphasizes the design by employing natural patterns in the built environment. So, I would like to use Browning et al.'s (2014) 14 patterns of biophilic design as part of the experience of the built environment, which offers a practical criterion for me to design. Utilising light, shadows, shape, and materials affects the atmosphere of space. Interestingly enough, biomimicry and biophilia are similar in many ways. For instance, they sound identical; they all relate to nature. Moreover, most importantly, the use of biomimicry and biophilic effects in association with landscape architecture will encourage visitors to experience the space in a new way based on further sensory stimulation.

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9.0 List of Figures

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