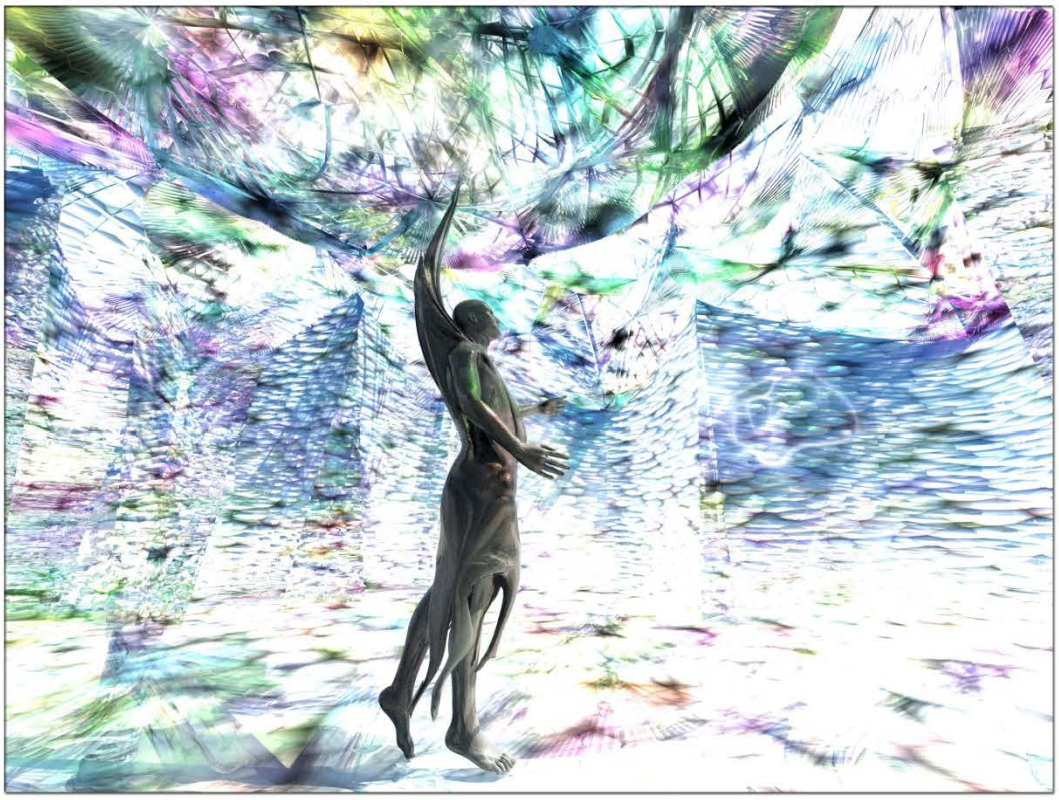

PROTEAN

The self-sufficient evolving urban space as a natural organism

(the living structure)

Mana Sookhakian

Master Programme Architecture and Urban Design
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2013
Master's thesis

THE GREAT VALUE OF LIFE IS TO SPEND IT ON SOMETHING THAT WILL OUTLAST IT

(JAMES TRUSLOW ADAMS)

PROTEAN

The self-sufficient evolving urban space as a natural organism (The living structure)

MANA SOOKHAKIAN

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CONTENTS:

ABSTRACT:

In order to make urban spaces and architectural structures in this era more sufficient and sustainable, nature can be implemented as an inspiration in the design of architectural and urban bodies.

The urban context is regarded as an organism consisting of architectural elements that are treated as living systems, and this will create a sustainable functional complex.

The main goal would be to design a structure that not only is eco-friendly and sufficient but is also adaptable to different situations and conditions.

INTRODUCTION:

A virus, in order to survive in its host's body cell, must adapt and evolve by going through mutation, and changing the protein of its surface in a way that will trick the host cell into allowing the virus to attack it.

This living structure will act similar to a virus and will be able to react to its surrounding environment and evolve and adapt to different conditions such as different climates or different functions. It will even be able to respond to different user activities.

The different climatic conditions consist of a hot and humid climate such as Kish Island located at the southern part of Iran, a mild and humid climate such as Namak Abrood located at the northern part of Iran, and cold climate such as Gothenburg in Sweden.

The site where the structure is located in Gothenburg

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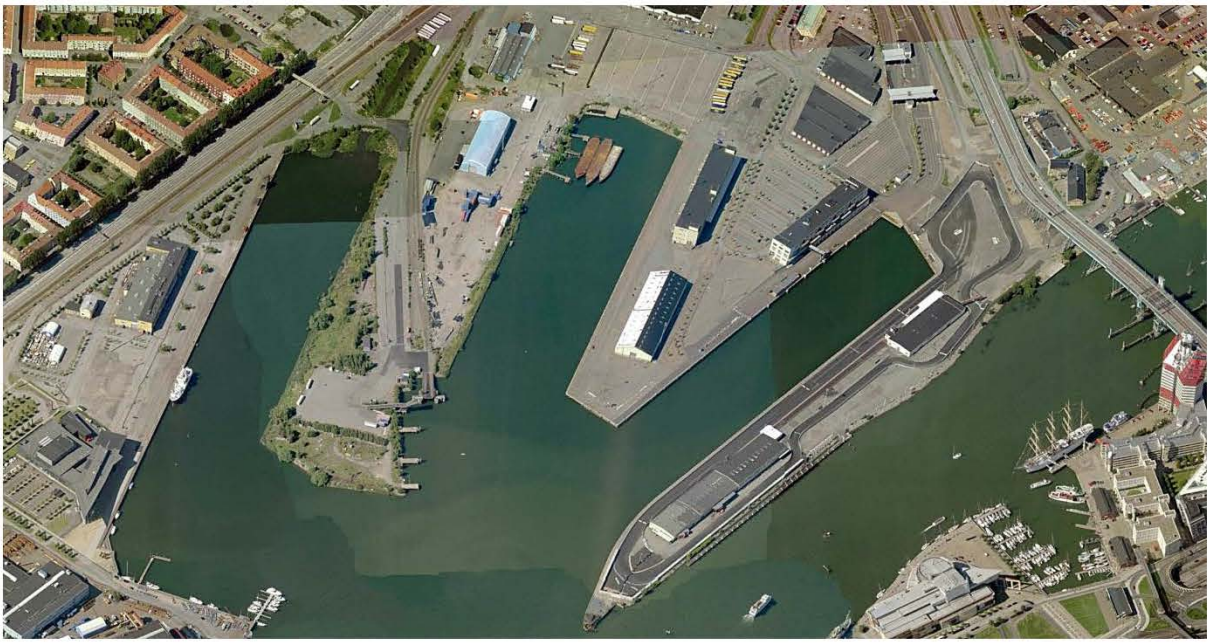


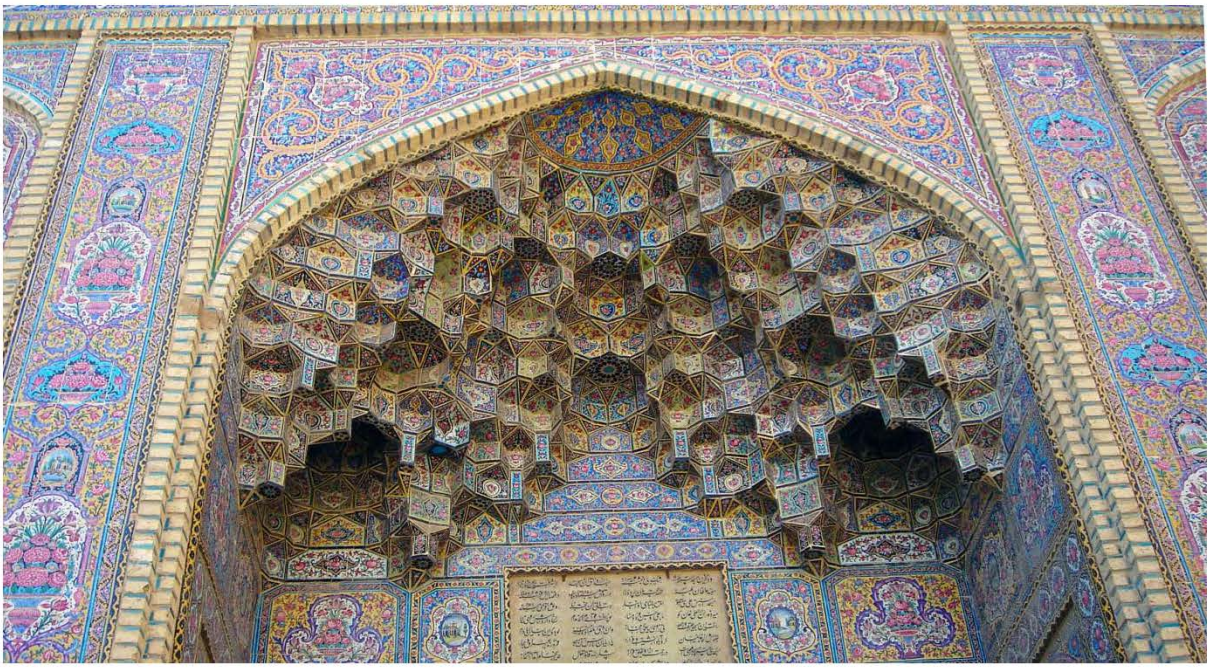
The site where the structure is located in Kish Island, south of Iran

The site where the structure is located in Namak Abrood, north of Iran

OBJECTIVES:

By studying the design of nature in traditional architecture (in this case Persian architecture), and contemporary technological advances and solutions and also by applying other approaches in the design such as studies in the field of mathematics, physics and biology and implementing the results that would be inspirational and useful in the design process, we will be able to create a structure capable of functioning as a living system that is adaptable to many situations and is not limited or bound to its surrounding but is able to evolve and mutate according to them and is also responsive through time.

Many inspirations can be found in Persian traditional architecture. One of them is Muqarnas. Muqarnas is an architectural element consisting of niche-like parts organized in tiers. In order to create a smooth transition between the rectangular section and the vaulted section in a dome structure, Muqarnas can be fitted into the dome.



Muqarnas in Persian architecture (Mana Sookhakian 2009)

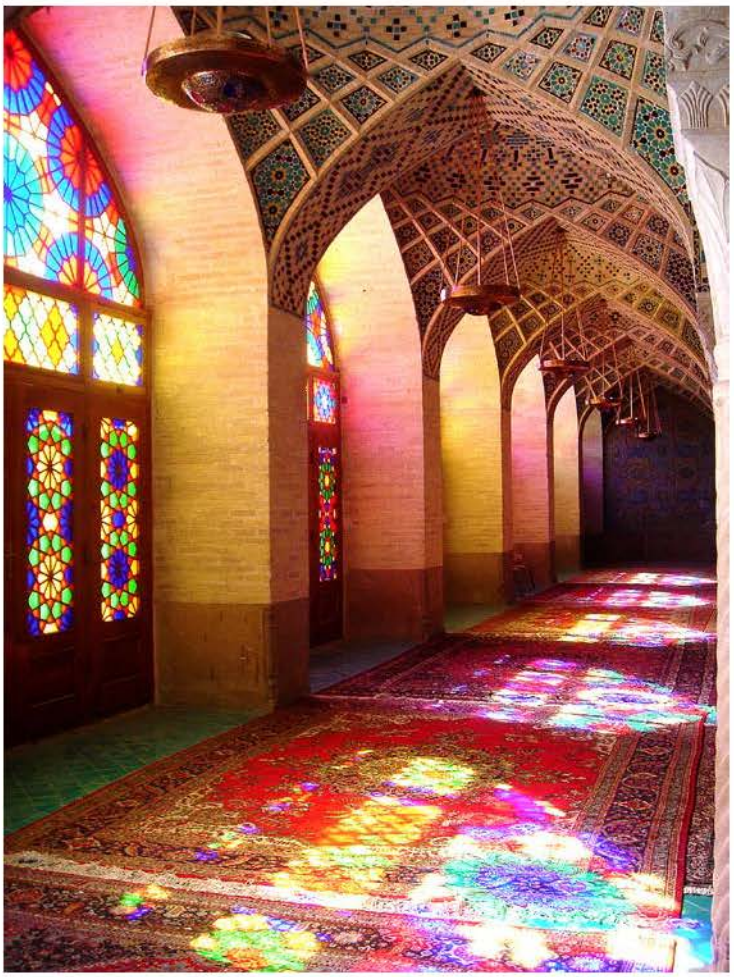
Muqarnas in Persian architecture (Mana Sookhakian 2009)

In the design of the living structure some design principles from traditional Persian architecture have been studied and implemented such as unity, centralism, geometry, light, continuity, transparency, reflection, weightlessness….

Persian architects have exhibited the concept of unity in buildings by demonstrating unity turning into multiplicity and multiplicity returning to unity. In Persian architecture, each individual element is a complete form in its entirety yet with the multiplicity of these individual elements and their intricate arrangement a harmonious united complex structure is created.

The interest in geometry in Persian architecture has been shown by the balanced designs of the structural and ornamental architectural elements that pay equal attention to both positive and negative spaces.

Light plays a very important role in Persian architecture as it creates transparency and weightlessness in the structure. Light not only influences the structural design but it also has a psychological effect as well.



The role of light in Persian architecture (Mana Sookhakian 2009)

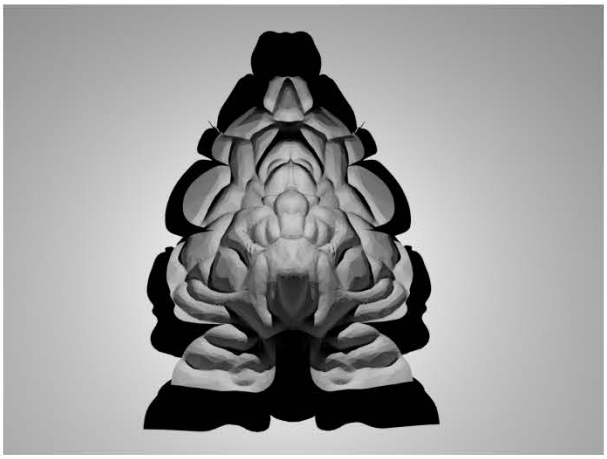
The role of geometry in Persian architecture (Mana Sookhakian 2009)

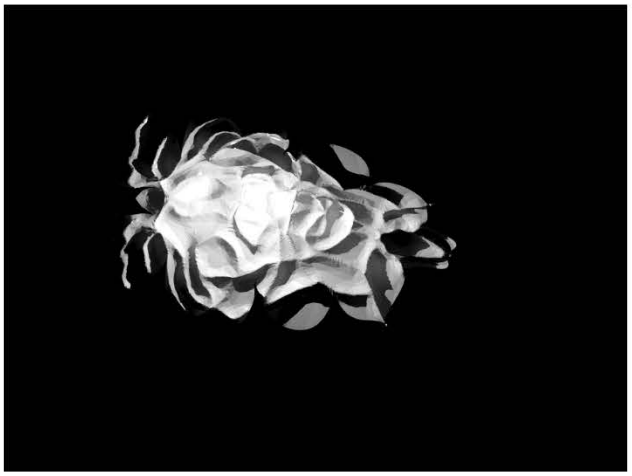
DESIGN PROCESS:

Design ideas are based on studies in mathematics, physics, designs of nature, traditional architecture and current technological advances.

ORIGINAL DESIGNS FOR THE FORM OF THE STRUCTURE:

With inspiration from fractal mathematical formulas in nature (like the spiral aloe…) and by applying different fractal formulas in mathematical programs and with regards to studies about Muqarnas in traditional Persian architecture as a static and structural element the following original designs that are similar to the fractals in nature and Muqarnas designs can be created.





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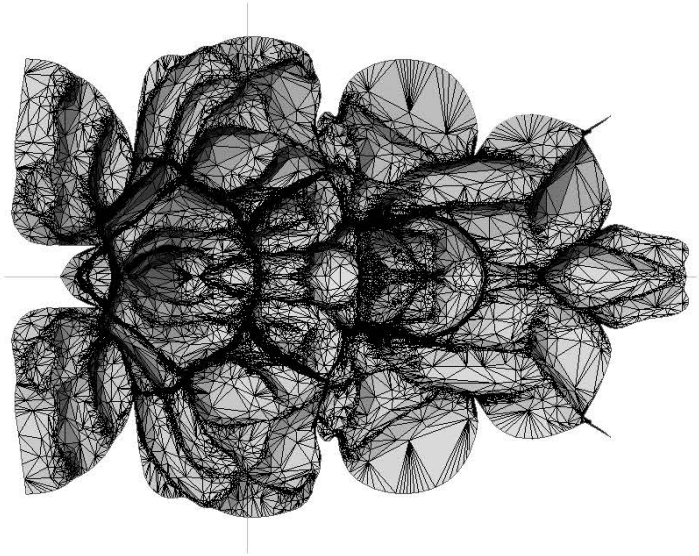

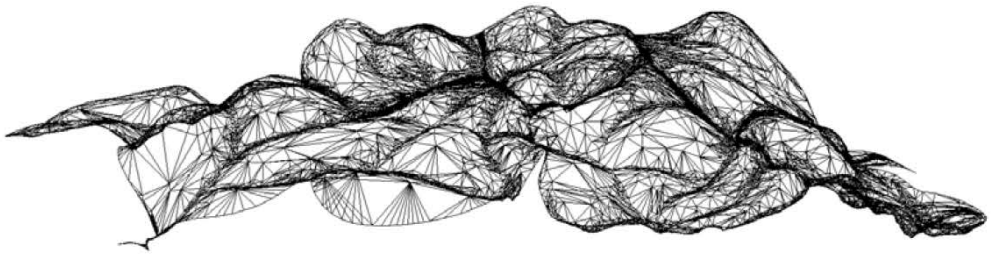

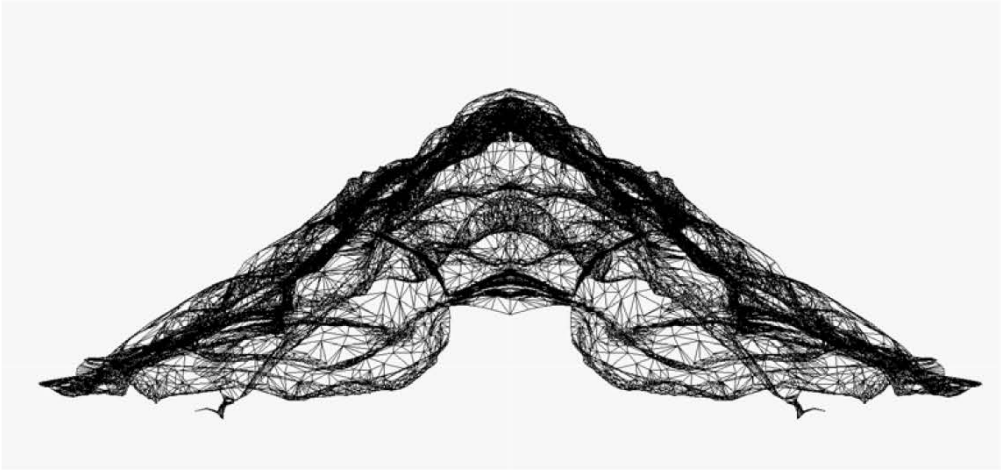

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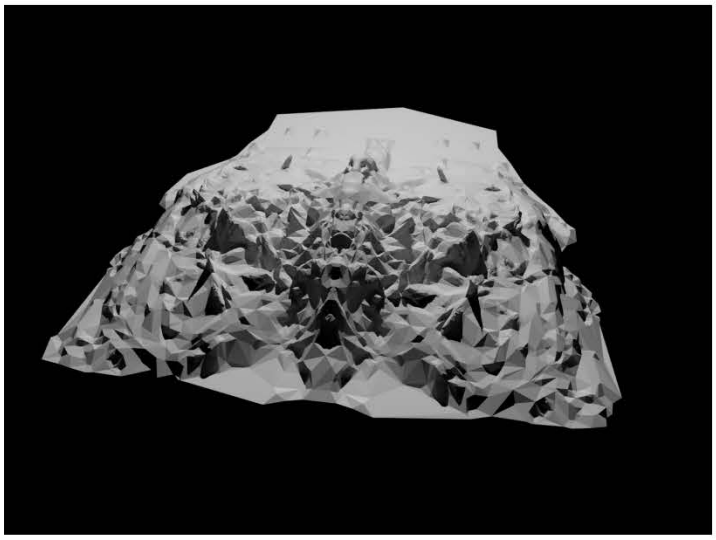

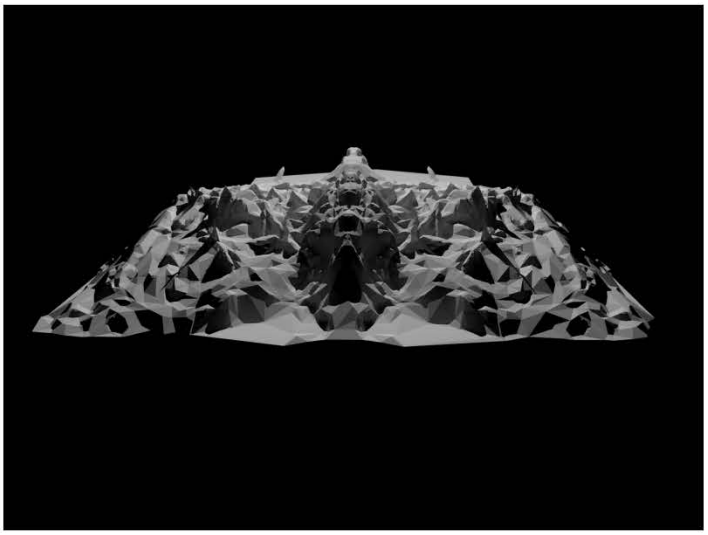

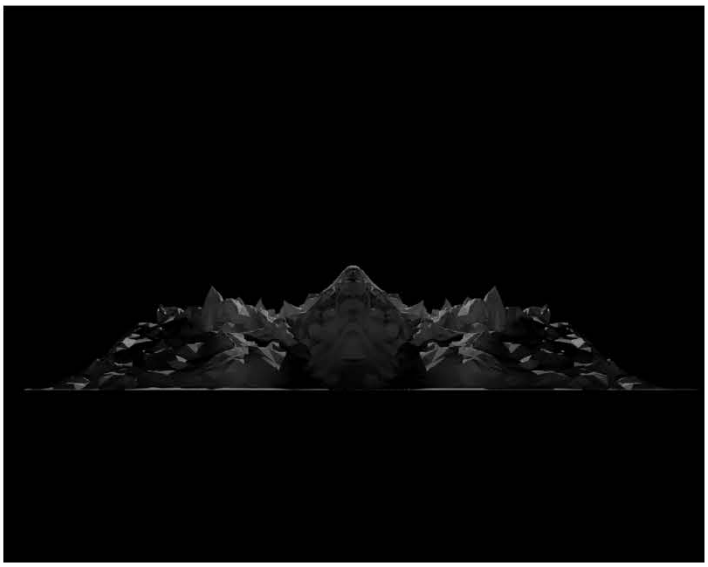

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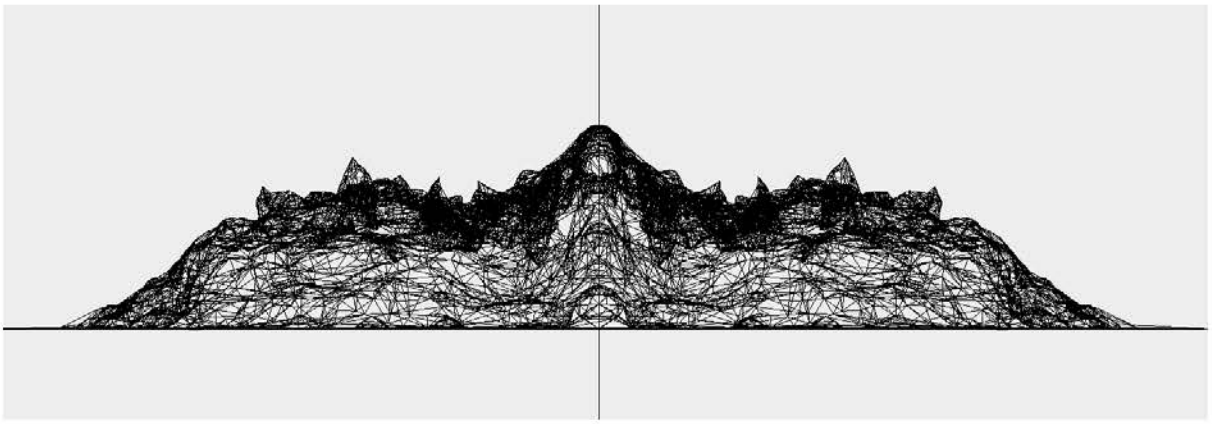

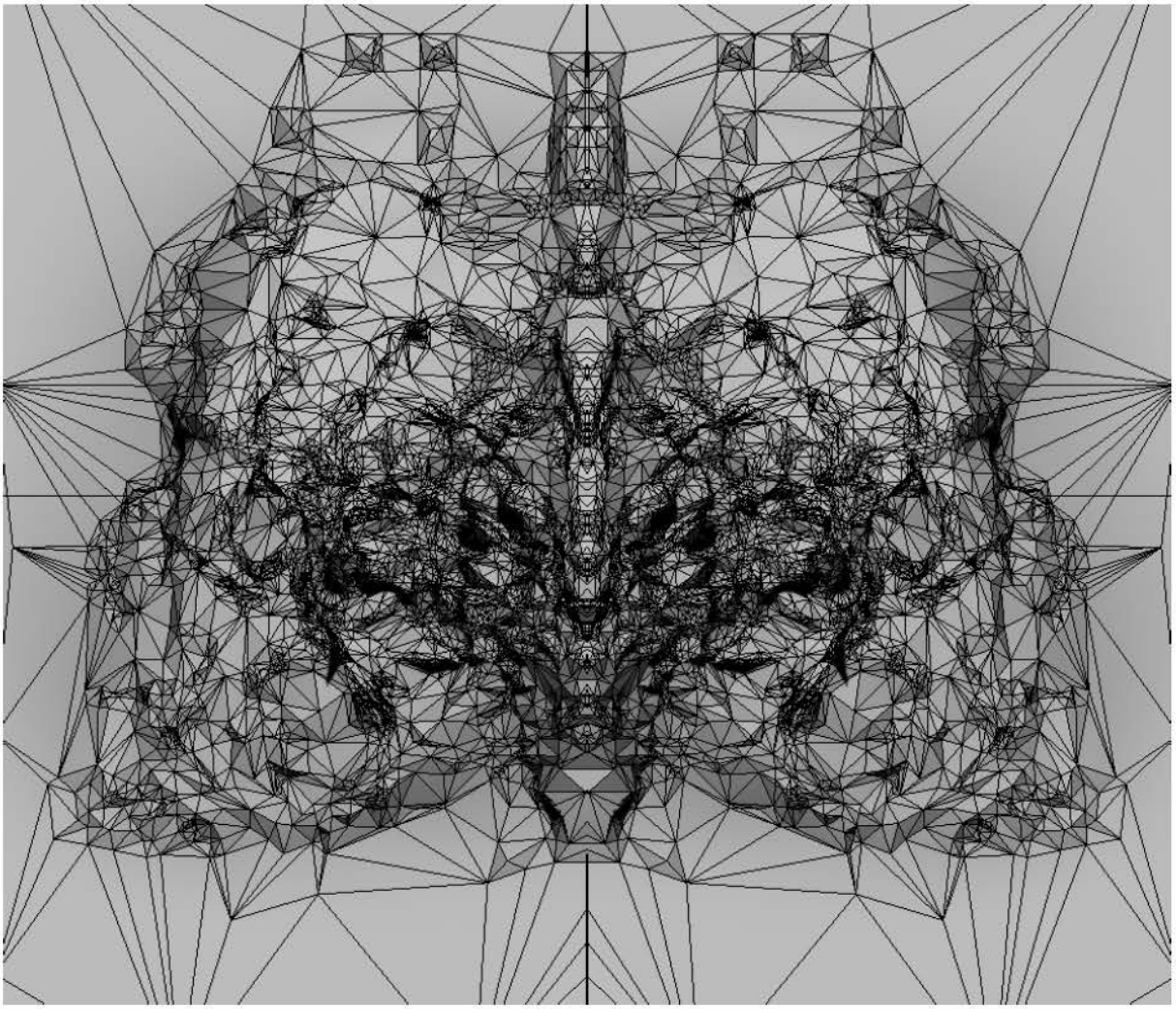

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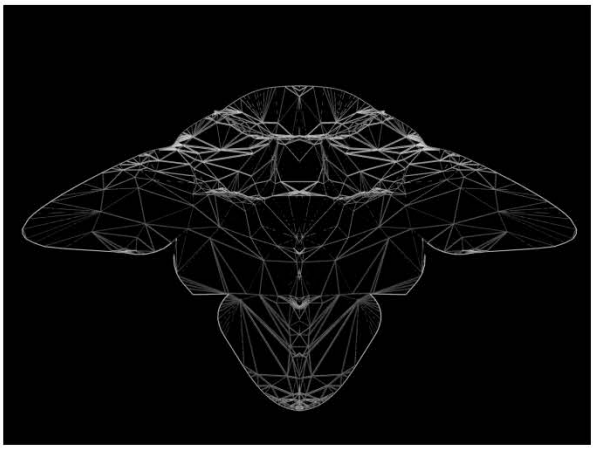

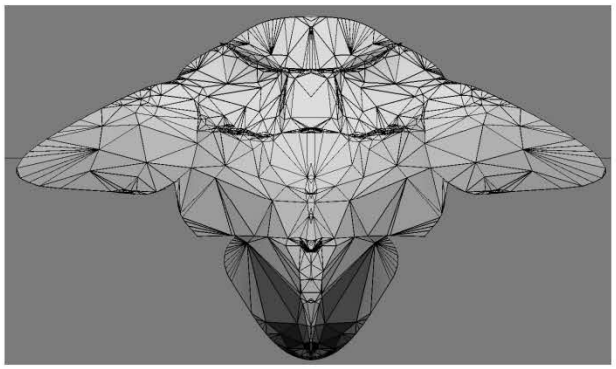

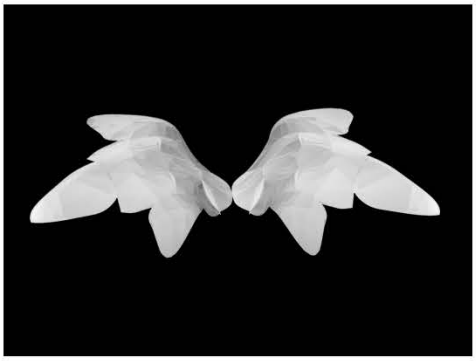

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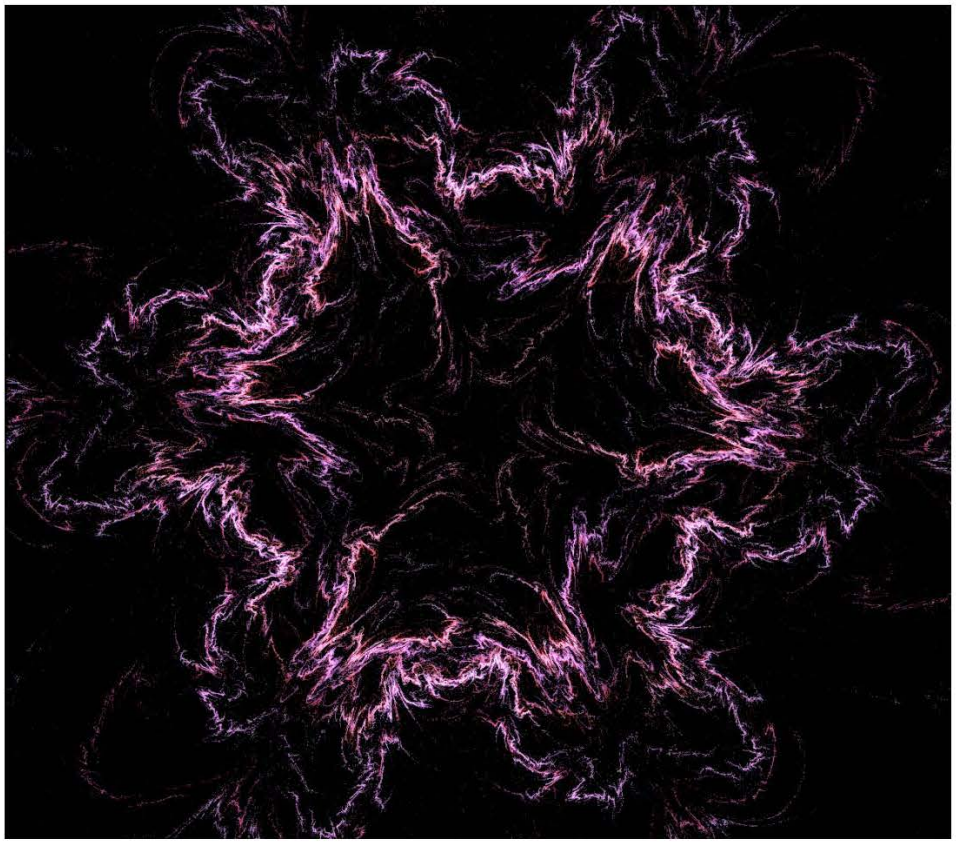

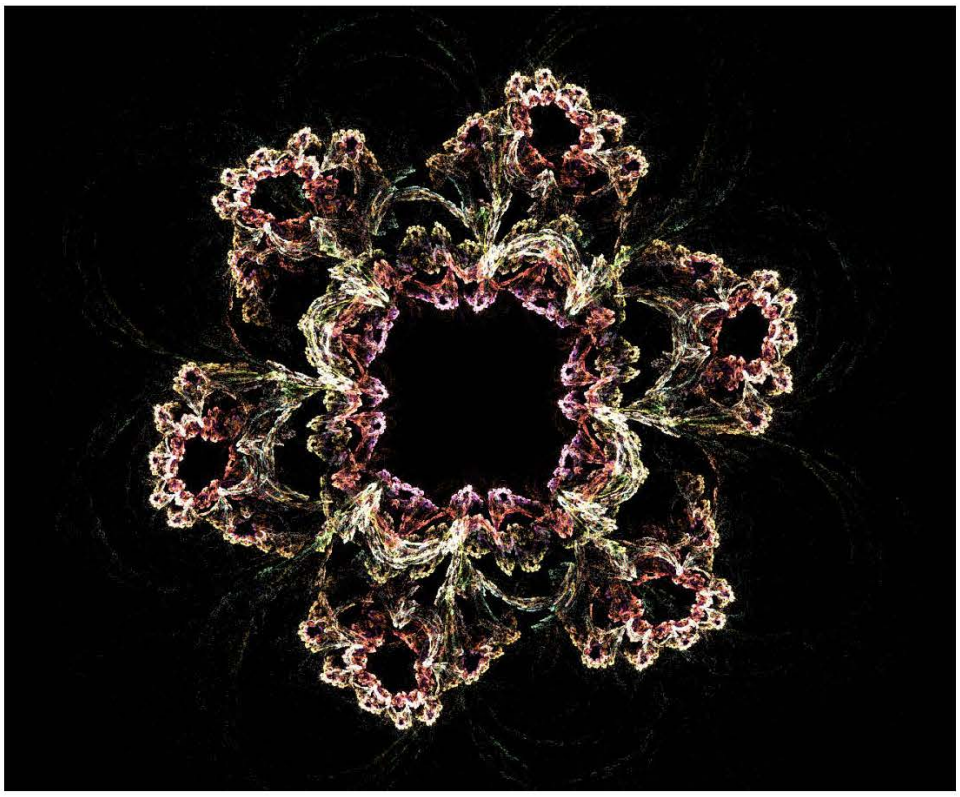

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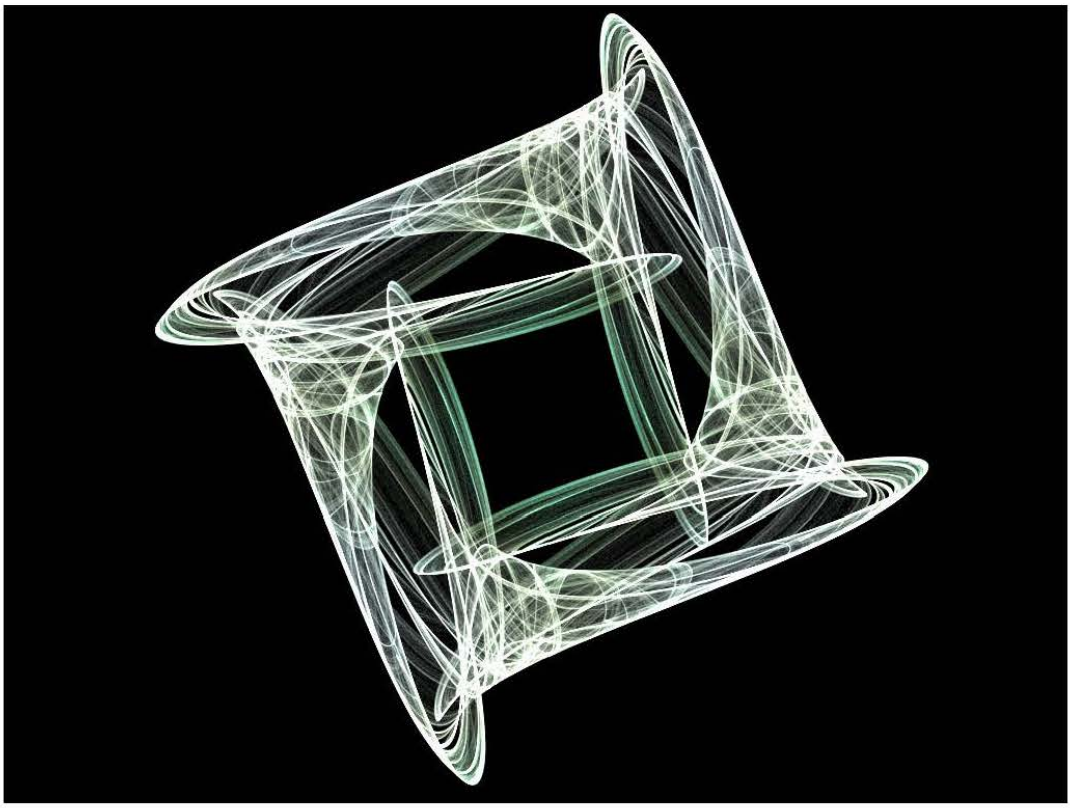

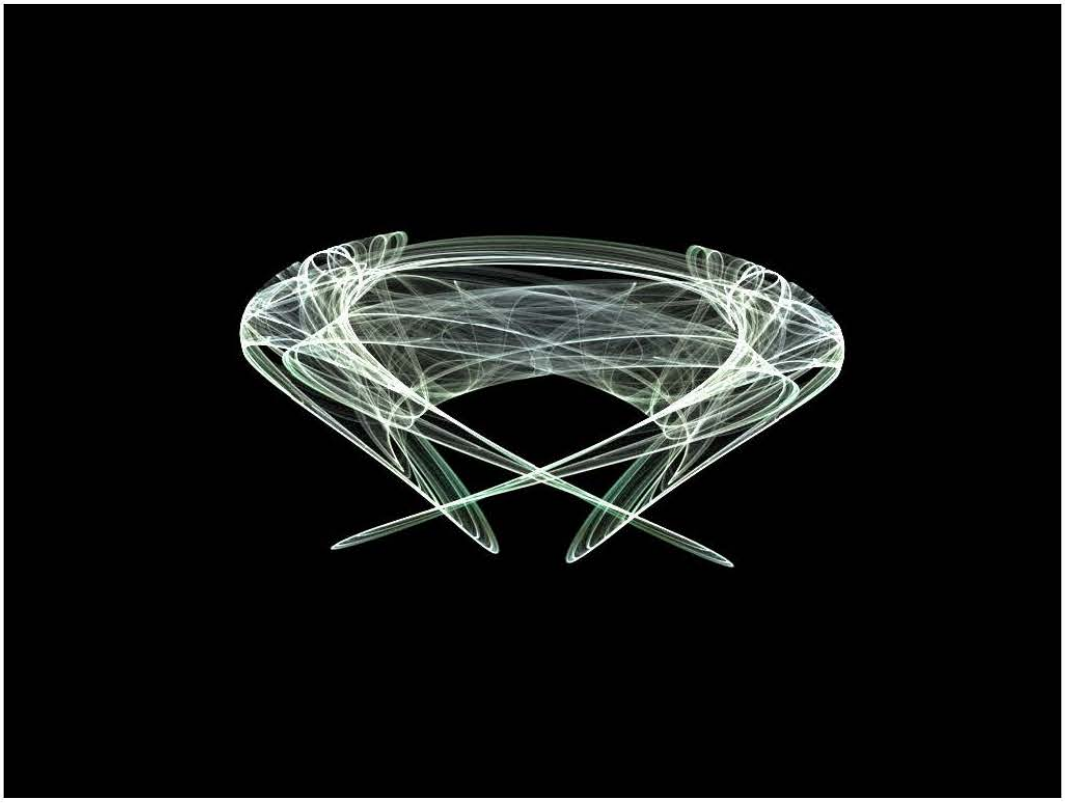

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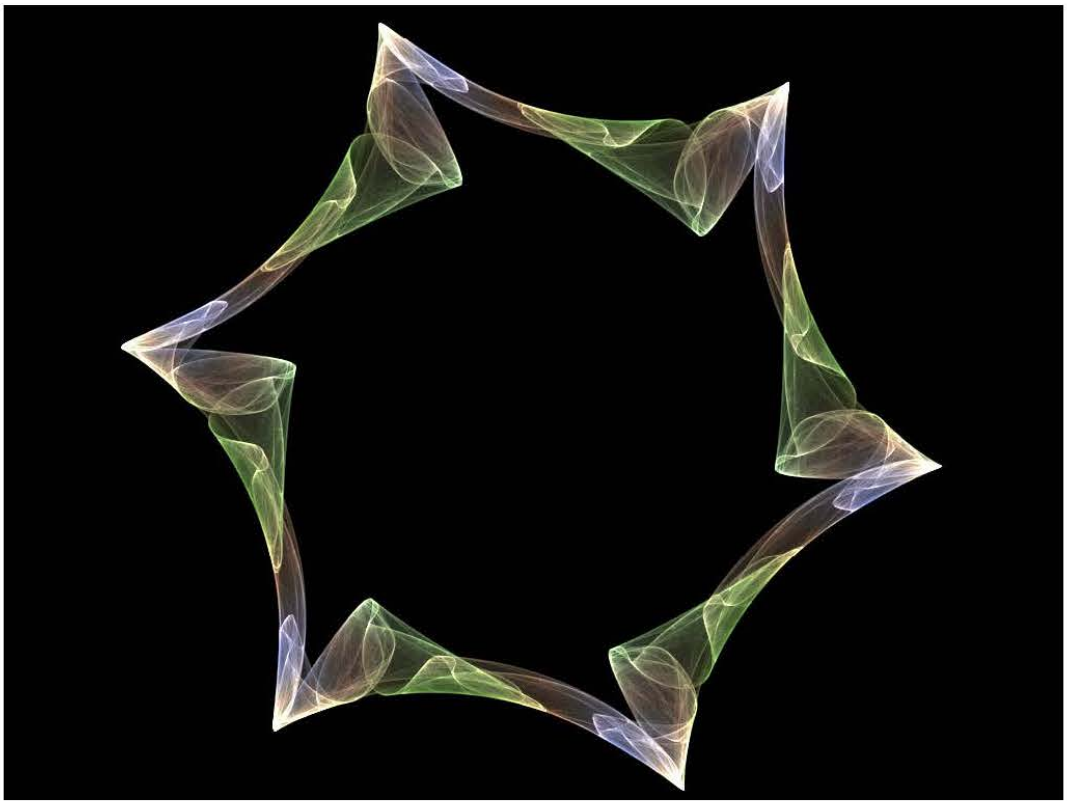

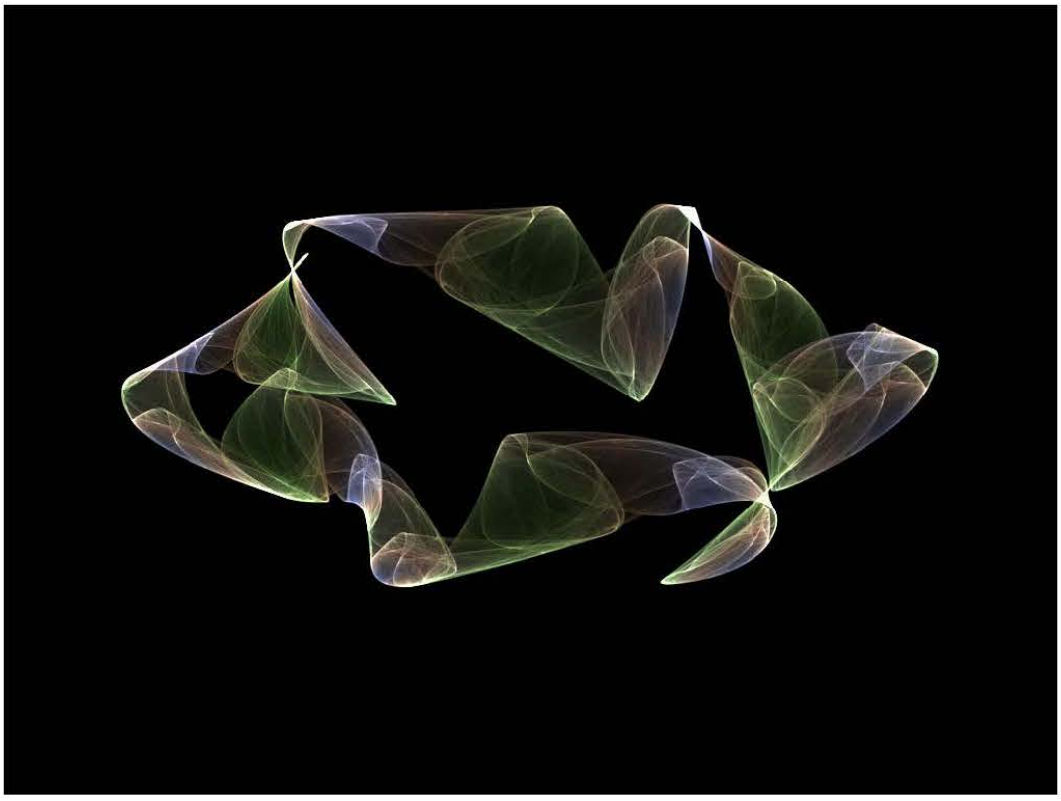

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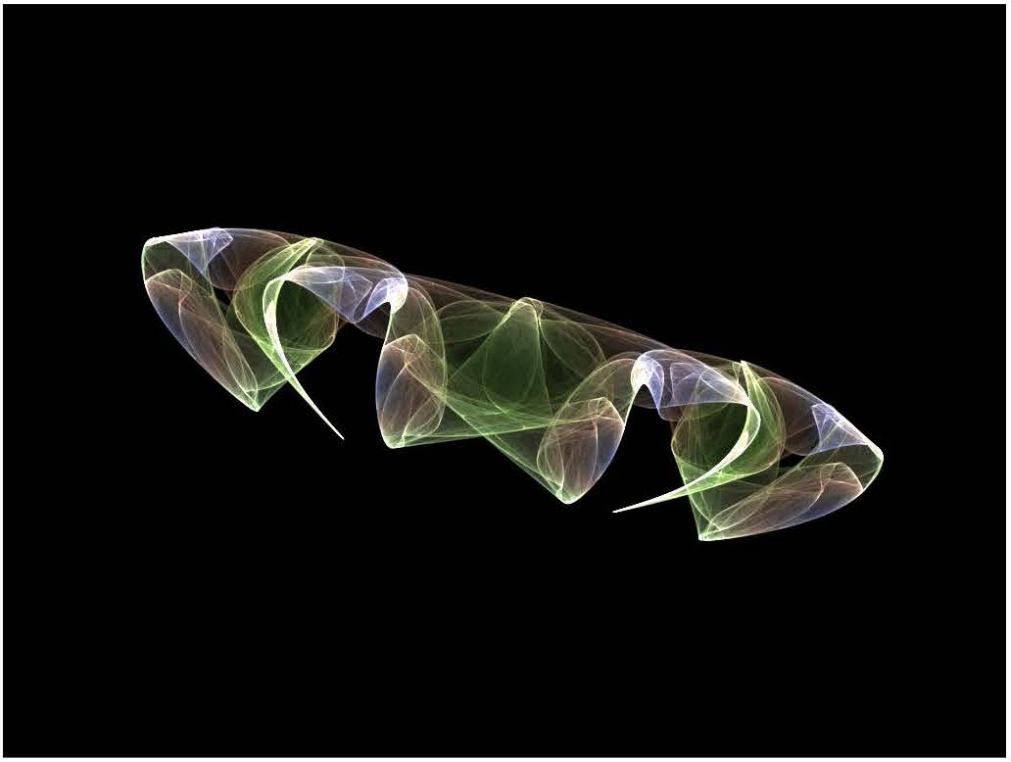

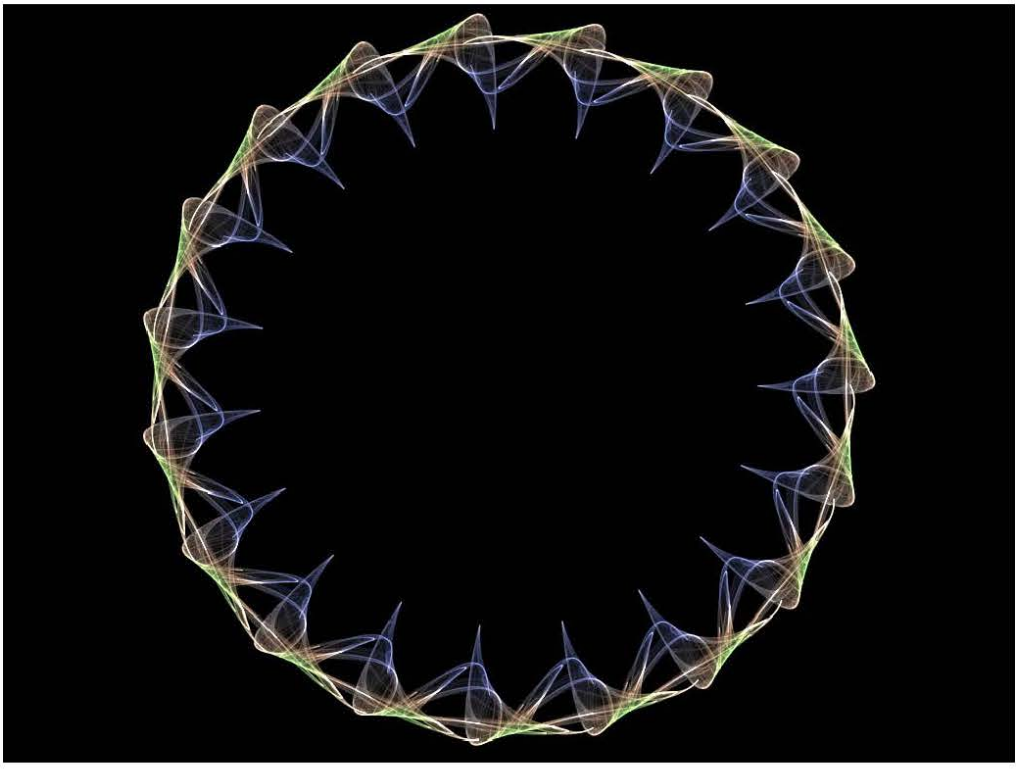

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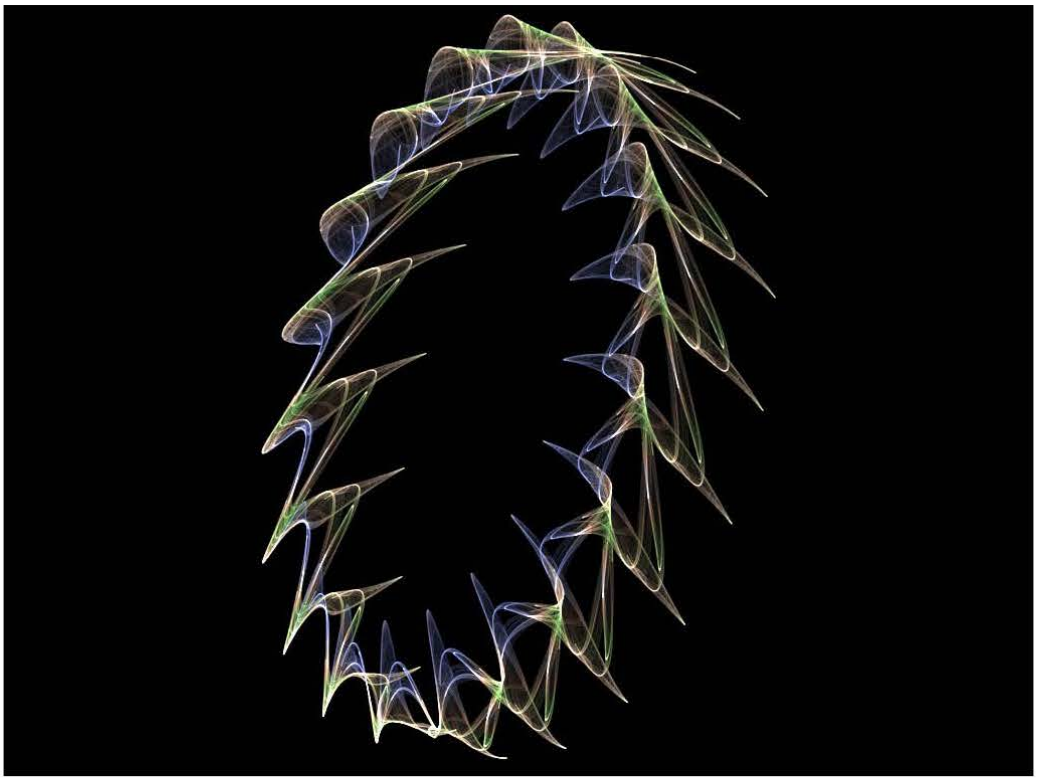

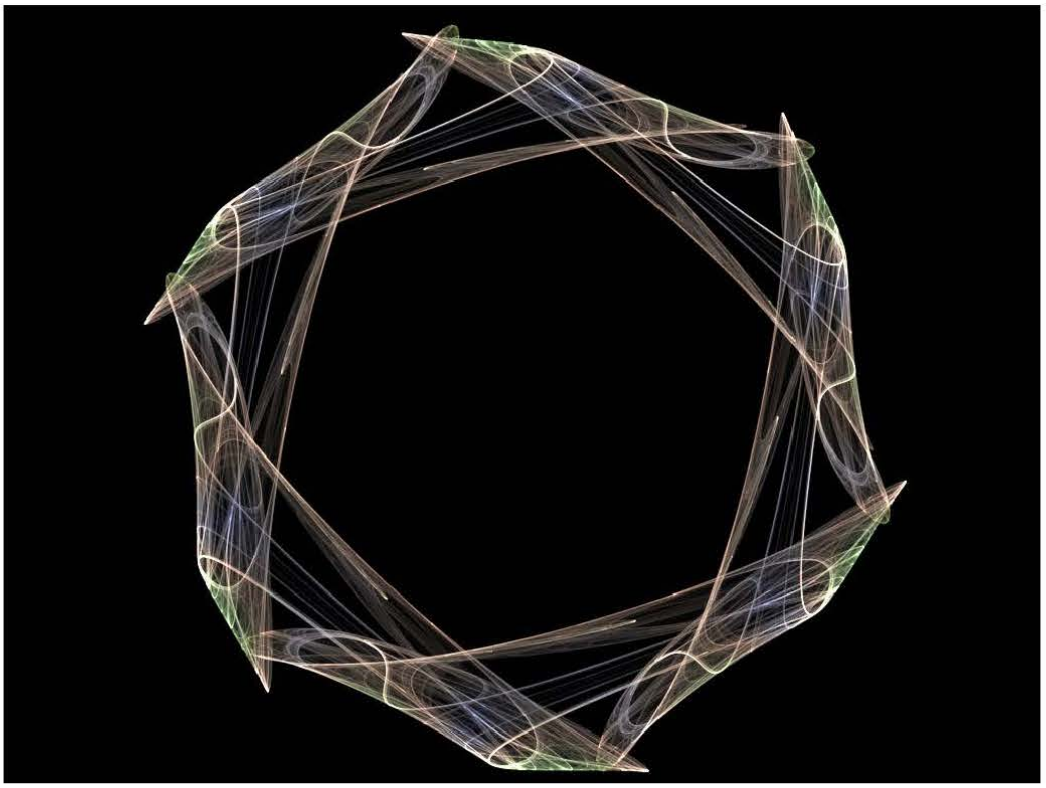

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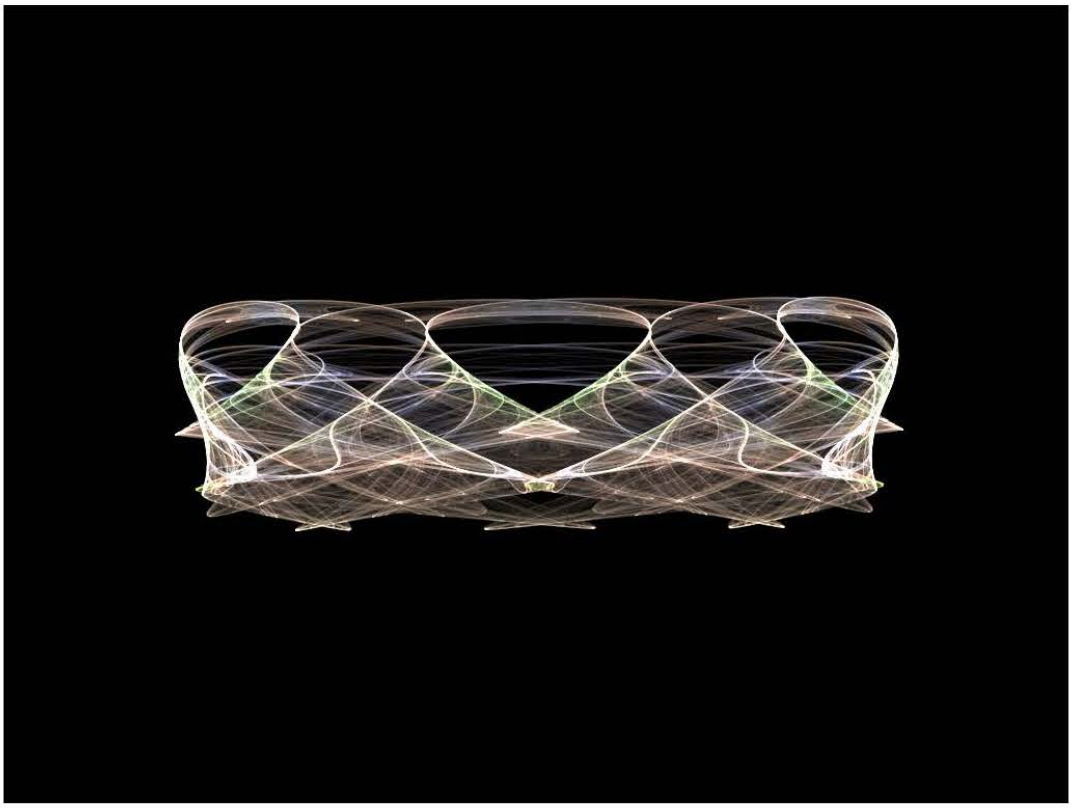

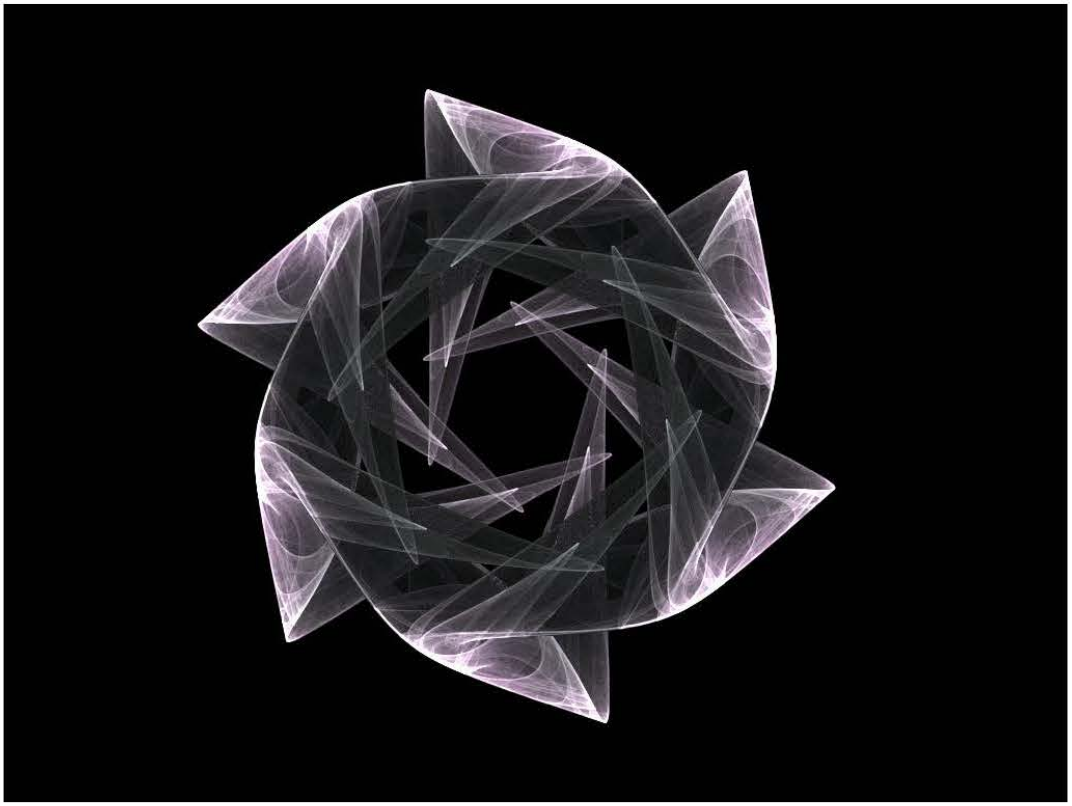

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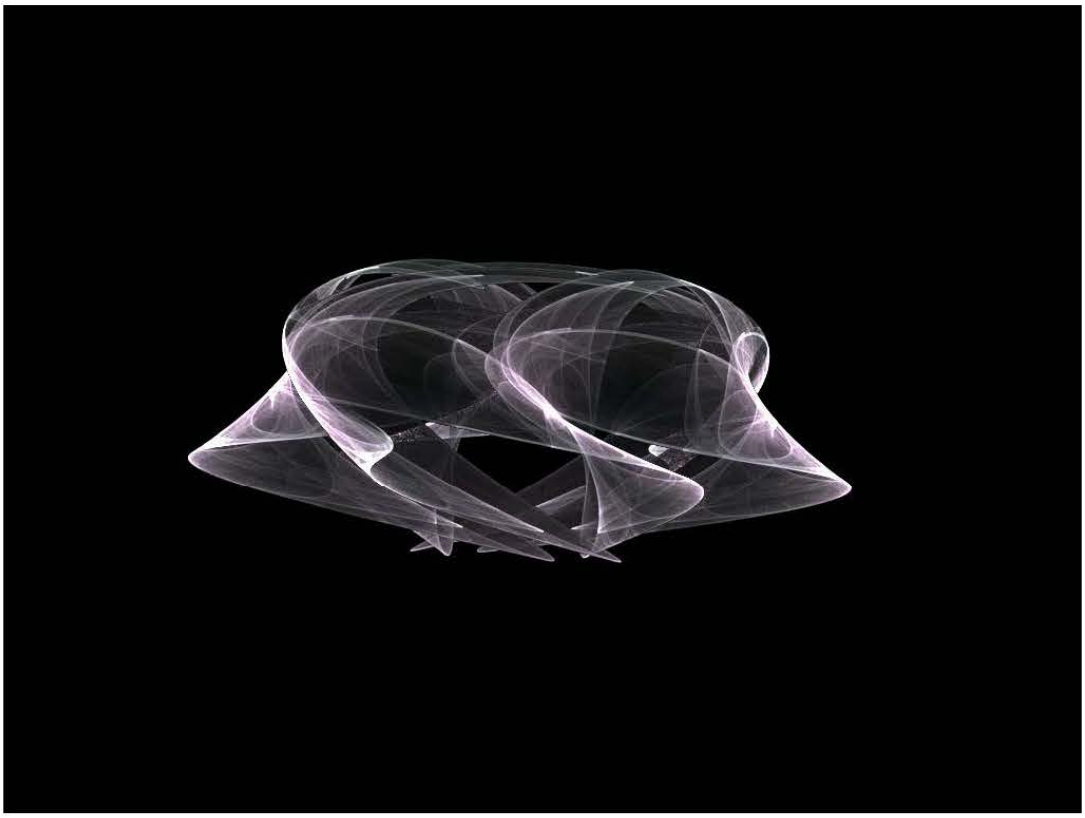

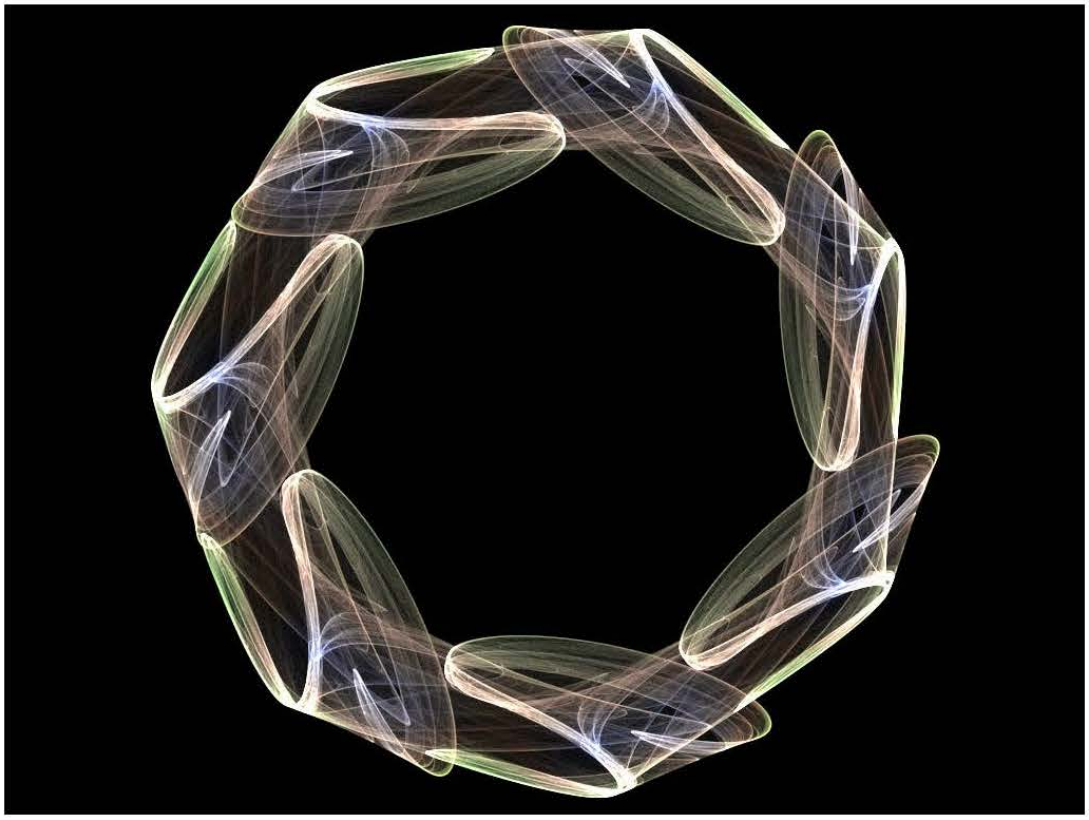

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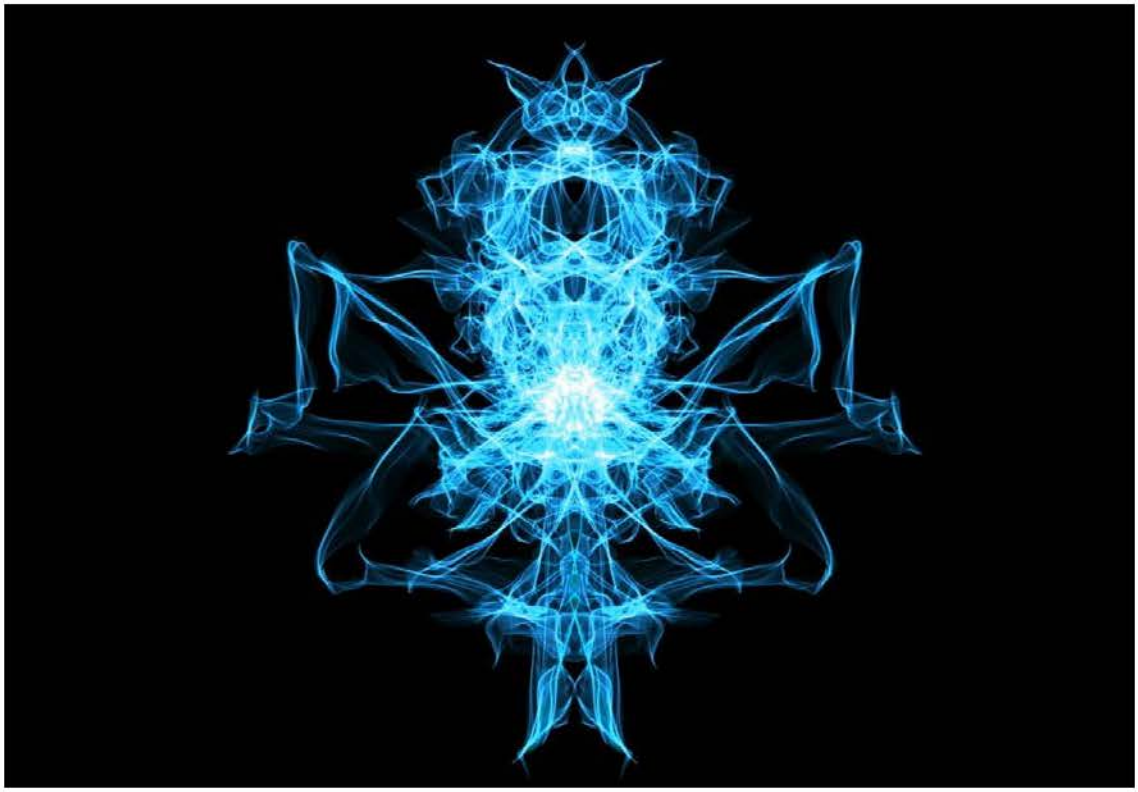
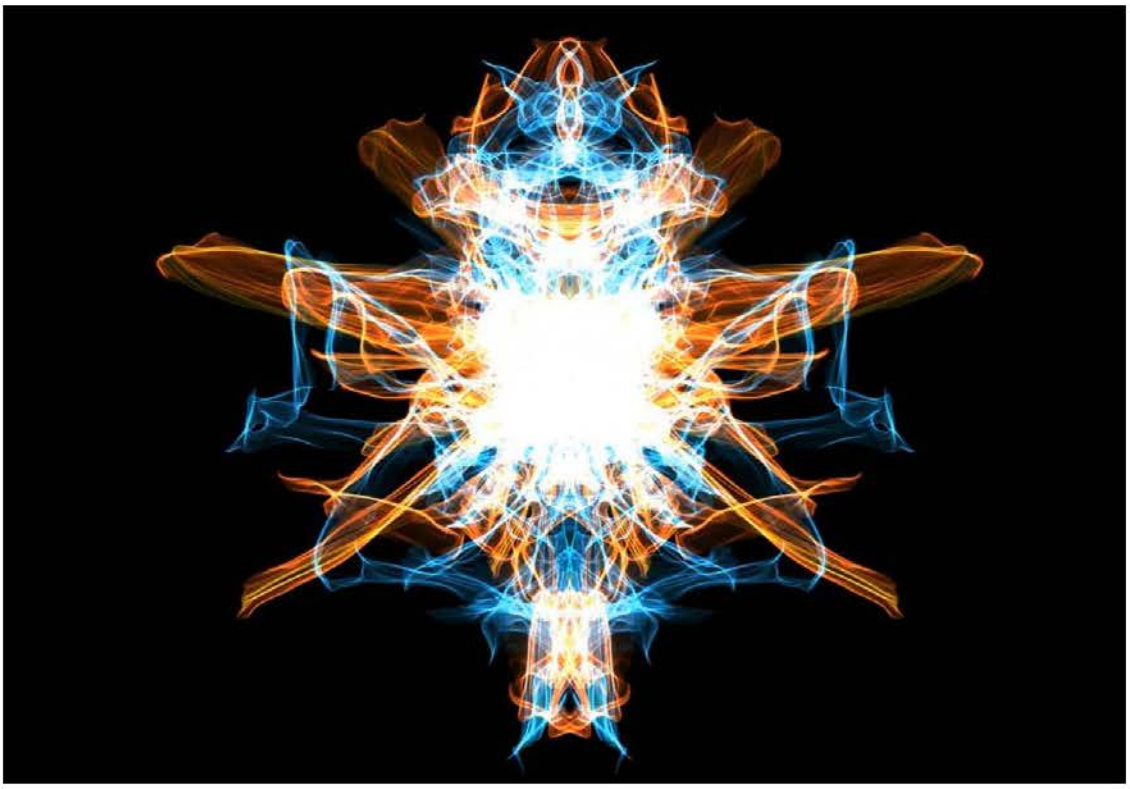
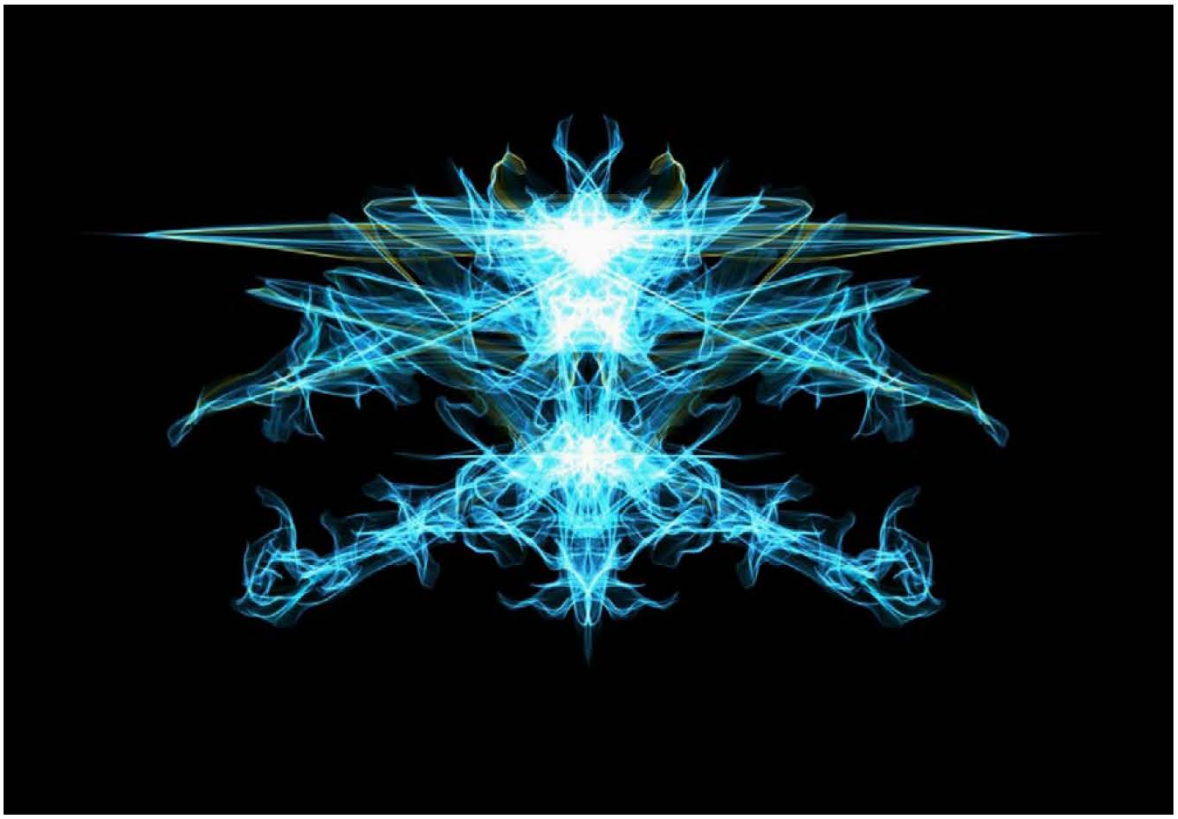




The sketches and graphic designs for the structure



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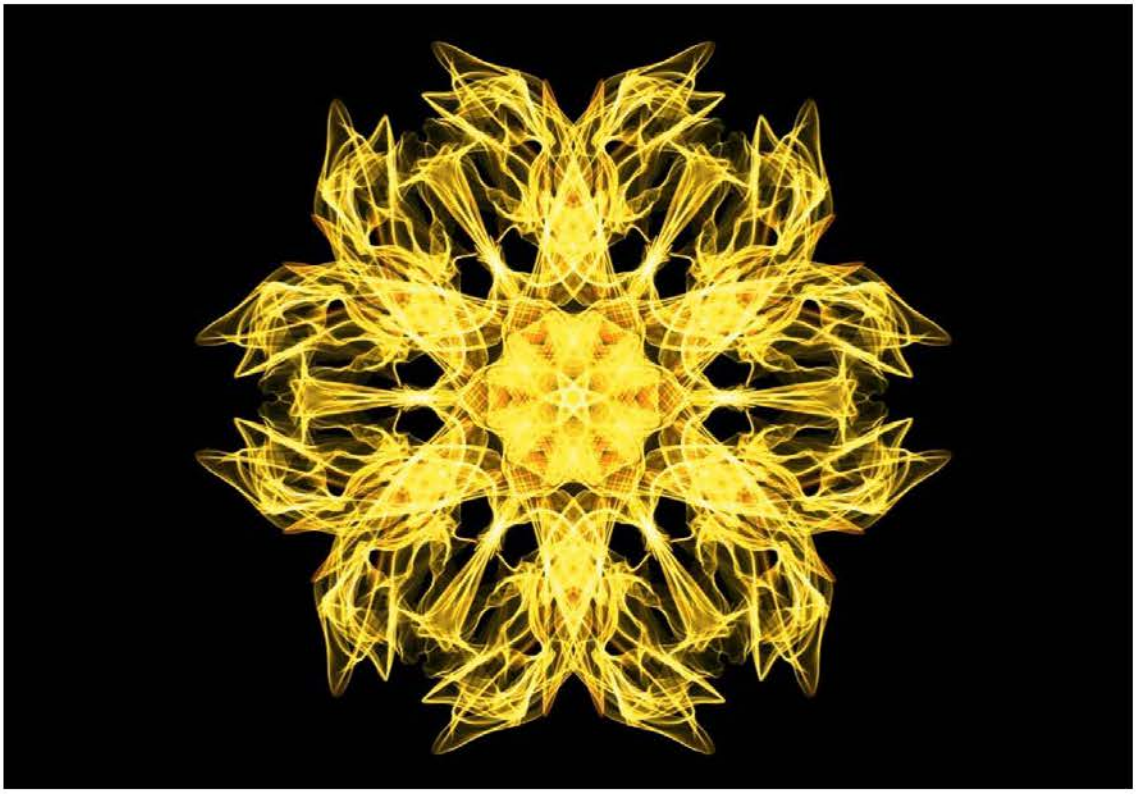

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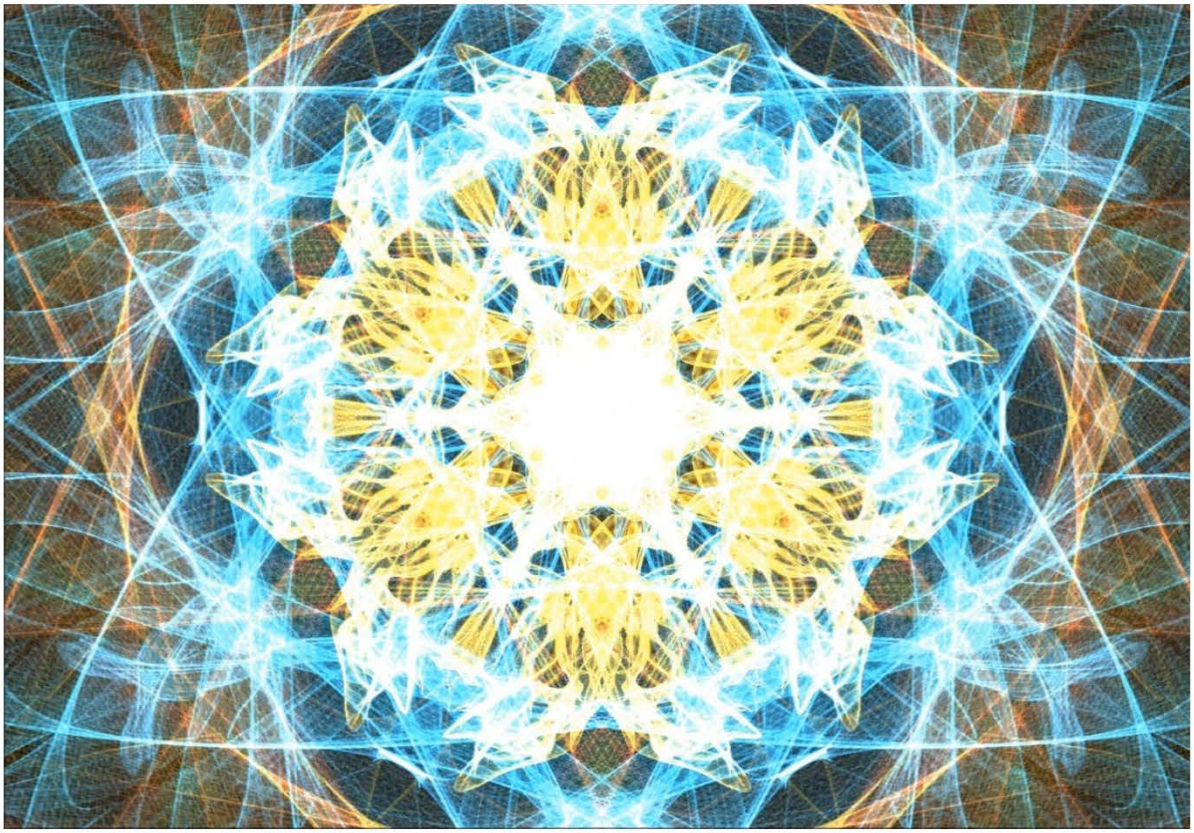

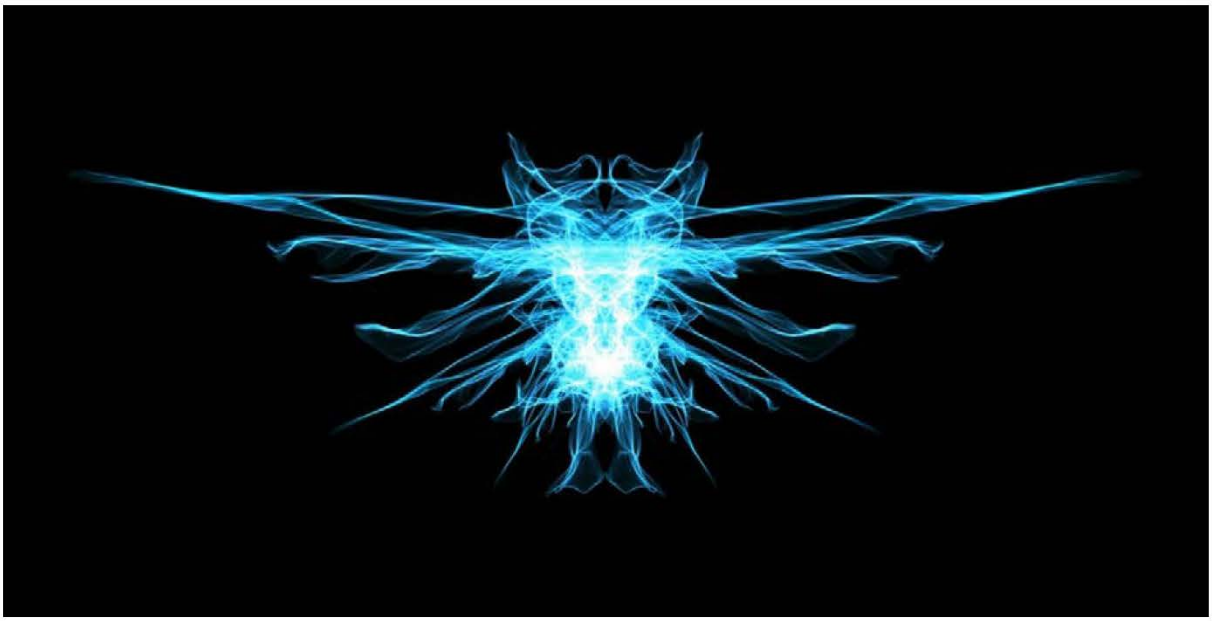

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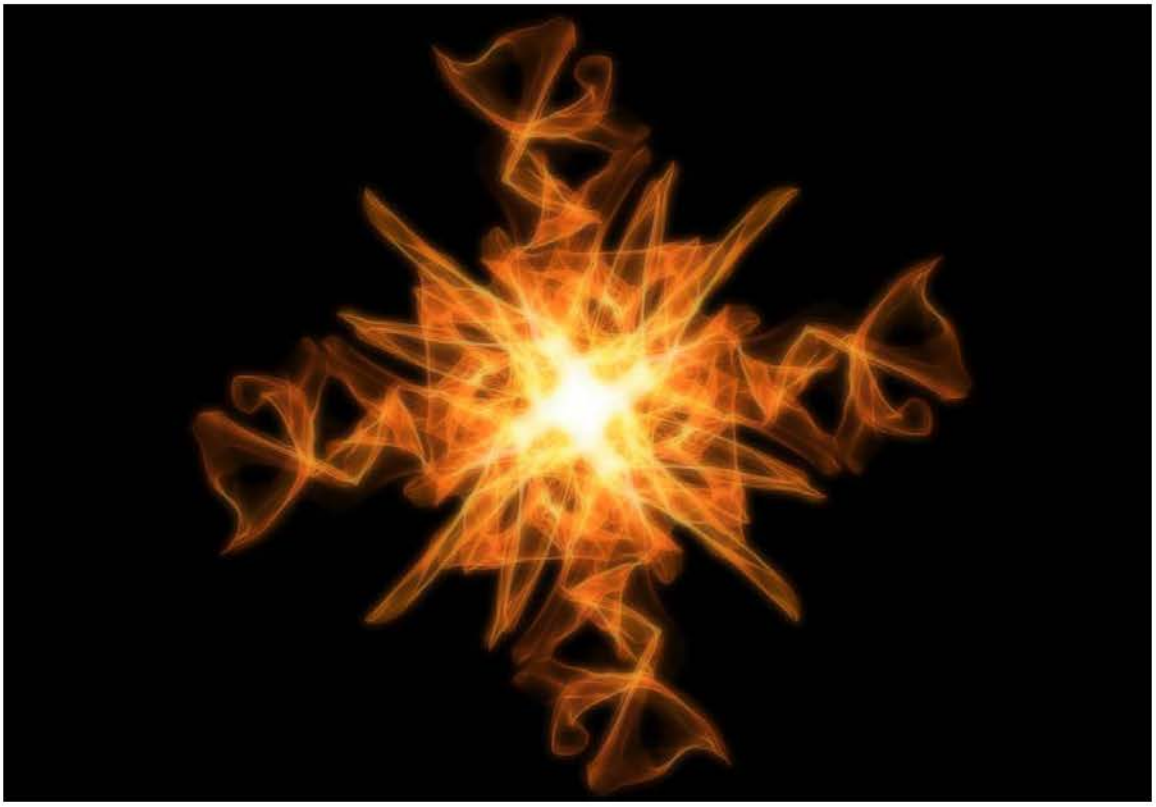

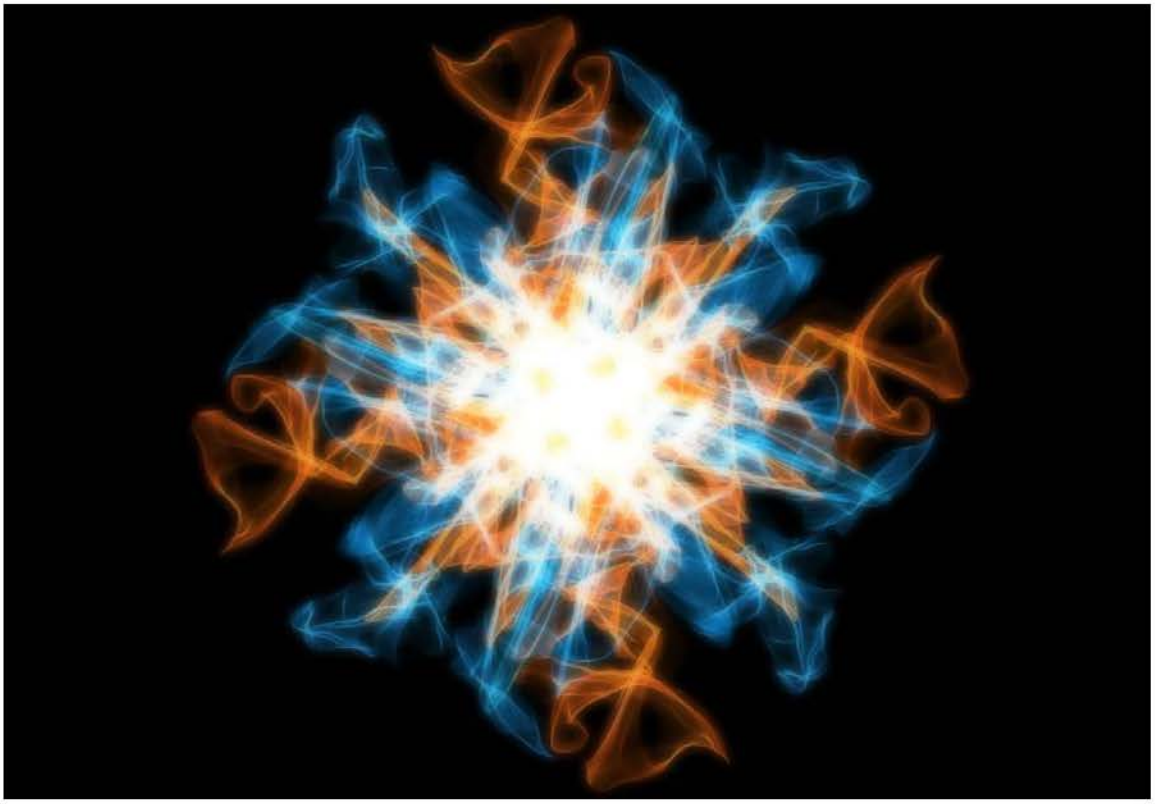

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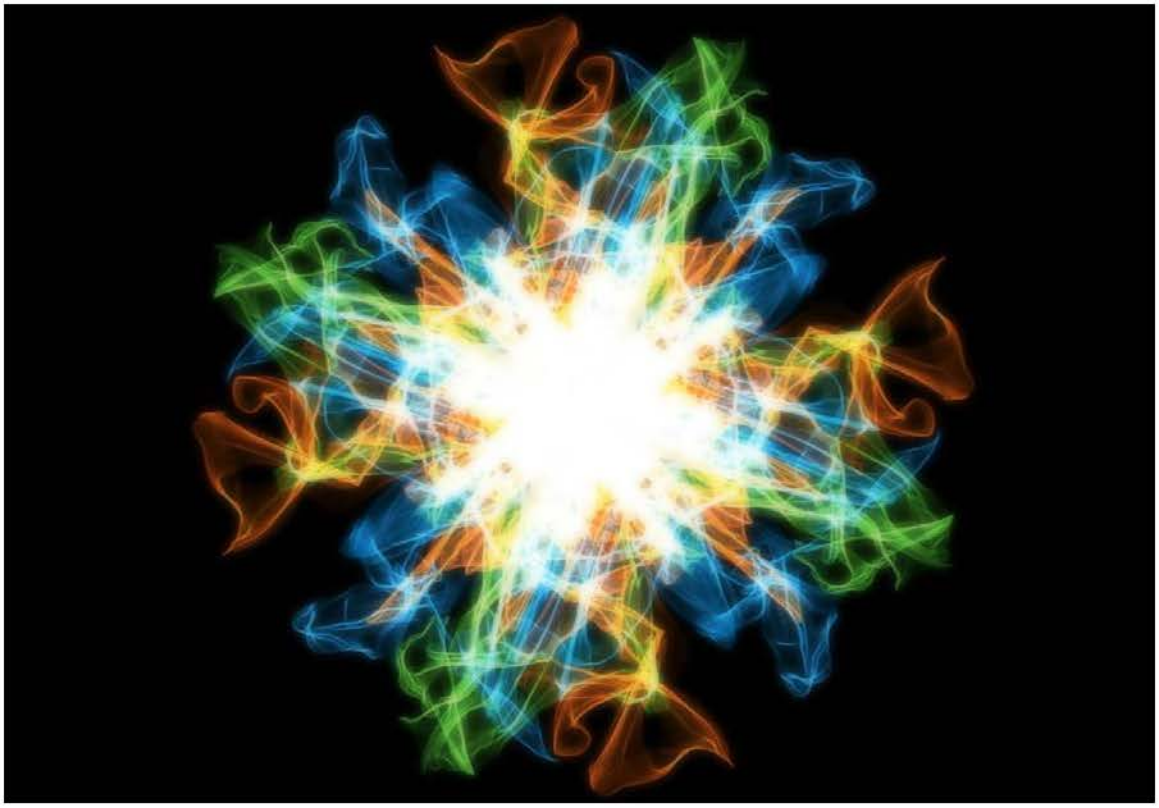
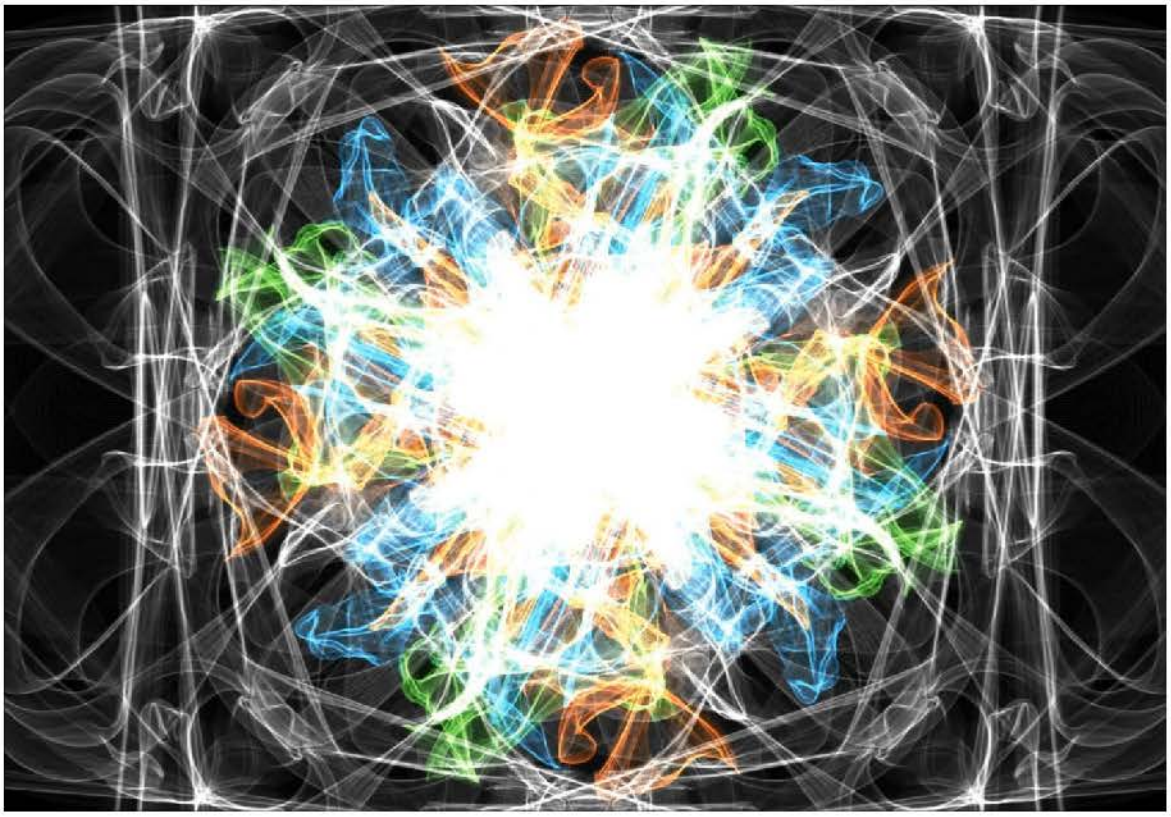




The sketches and graphic designs for the structure

ORIGINAL DESIGNS AND IDEAS:

Regarding the structural point of view, considering that this building should be able to adaptable to different environments and be portable, the structural parts are movable so the structure can mutate depending on different situations.

With the use of smart materials the surface of the structure can change transparency based on the environment and climate where the structure is located. For example in hot climates with sunshine, the use of photochromic, electrochromic and thermochromic materials in the surface can turn the surface opaque or reflective to protect the interior space from sunshine and heat. In cold climates the surface of the structure will turn transparent in order to allow the maximum amount of sunlight to get through while protecting the interior space from the wind and cold.

The smart materials used as the skin of the structure should be lightweight so the building will be able to move. The surface can also harvest energy with the use of these smart materials. These materials can be electrochromic, liquid crystal devices, and photochromic and thermochromic materials. They are able to regulate the temperature of the interior space efficiently and effectively and with the application of these materials and the form of the building the structure will become a structure with a neutral carbon footprint.

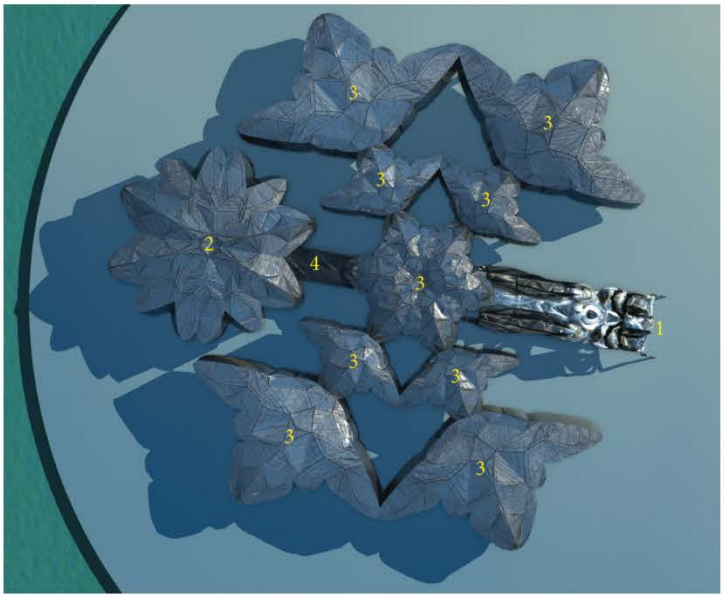
Different parts of the structure are as follow:

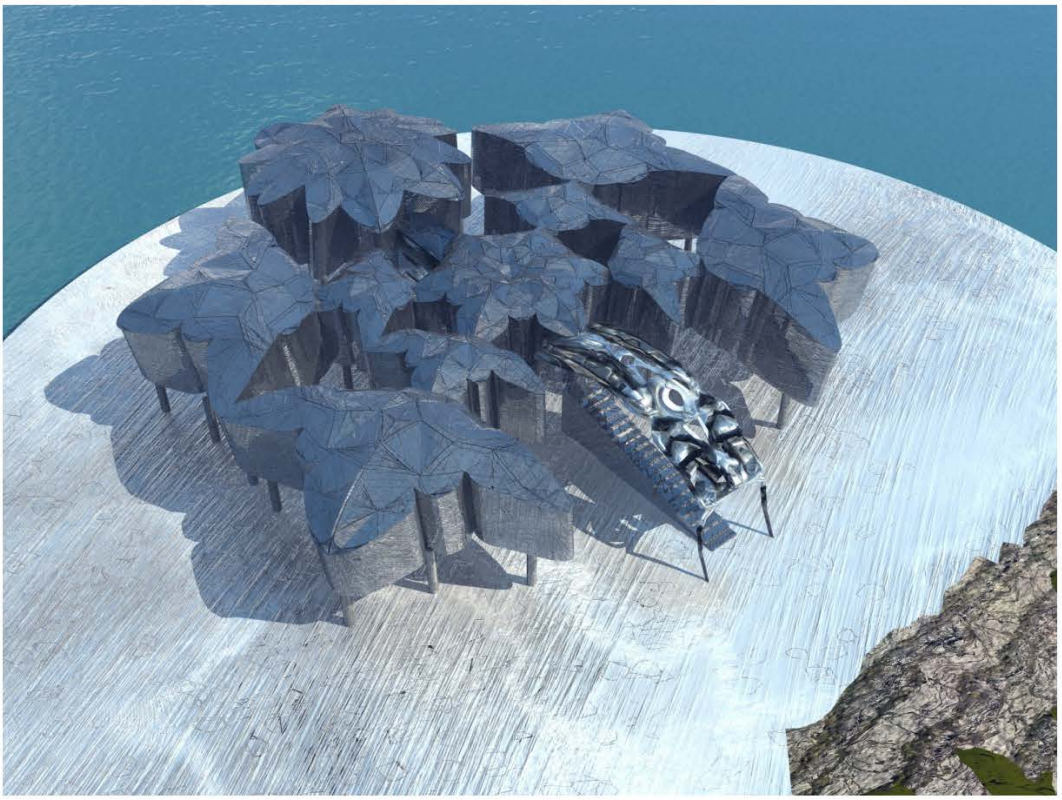
1. The entrance

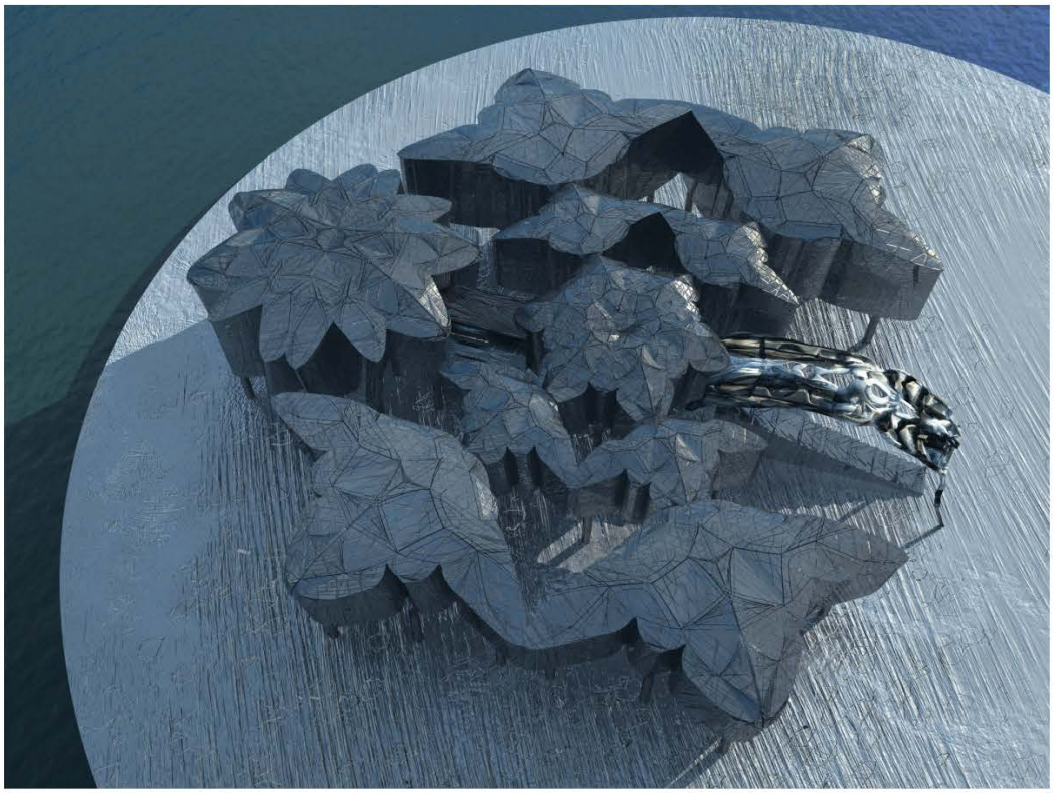
2. The main hall space

3. Small divided spaces for various functions

4. Tessellated corridor





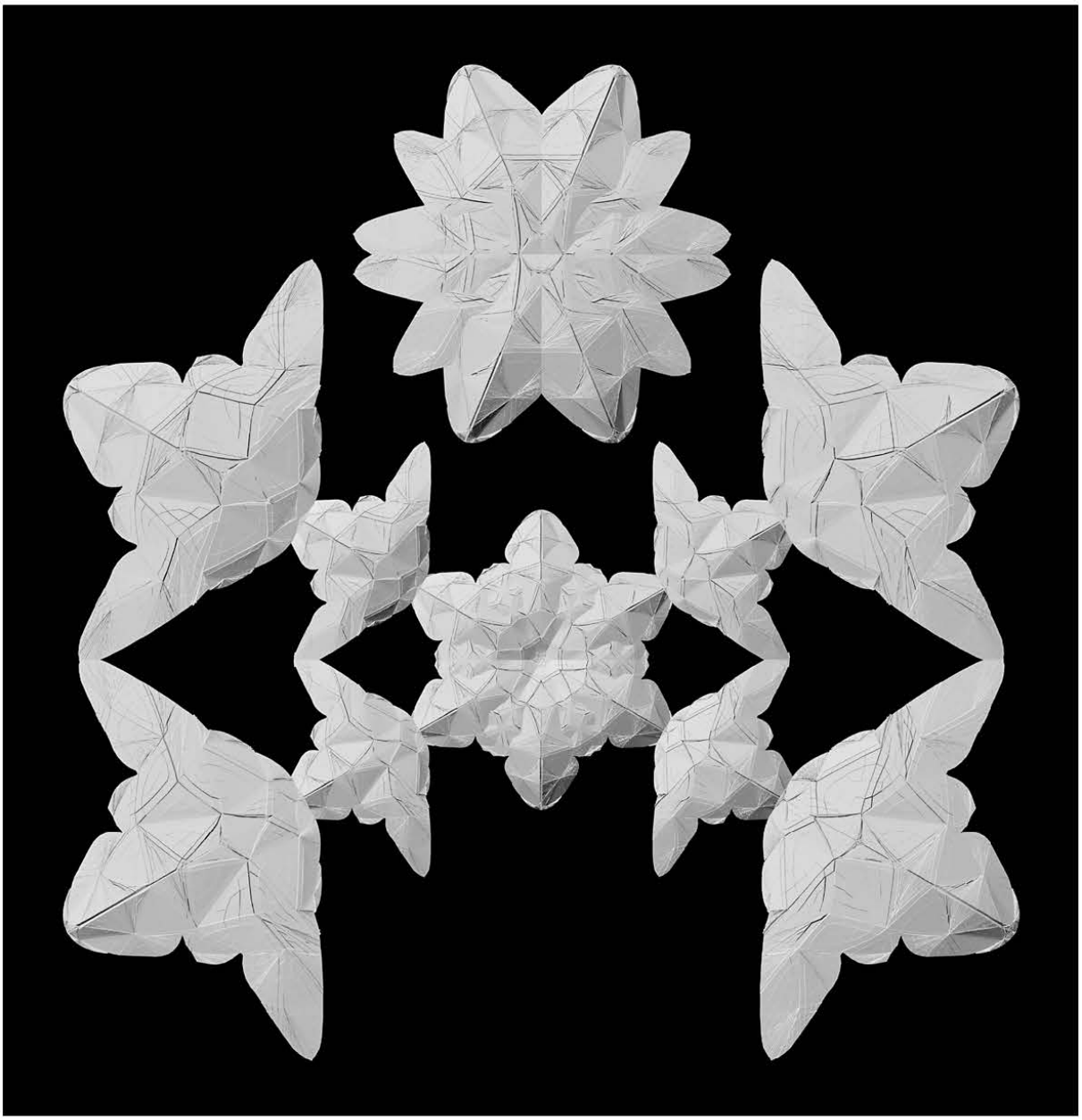


Views of the design

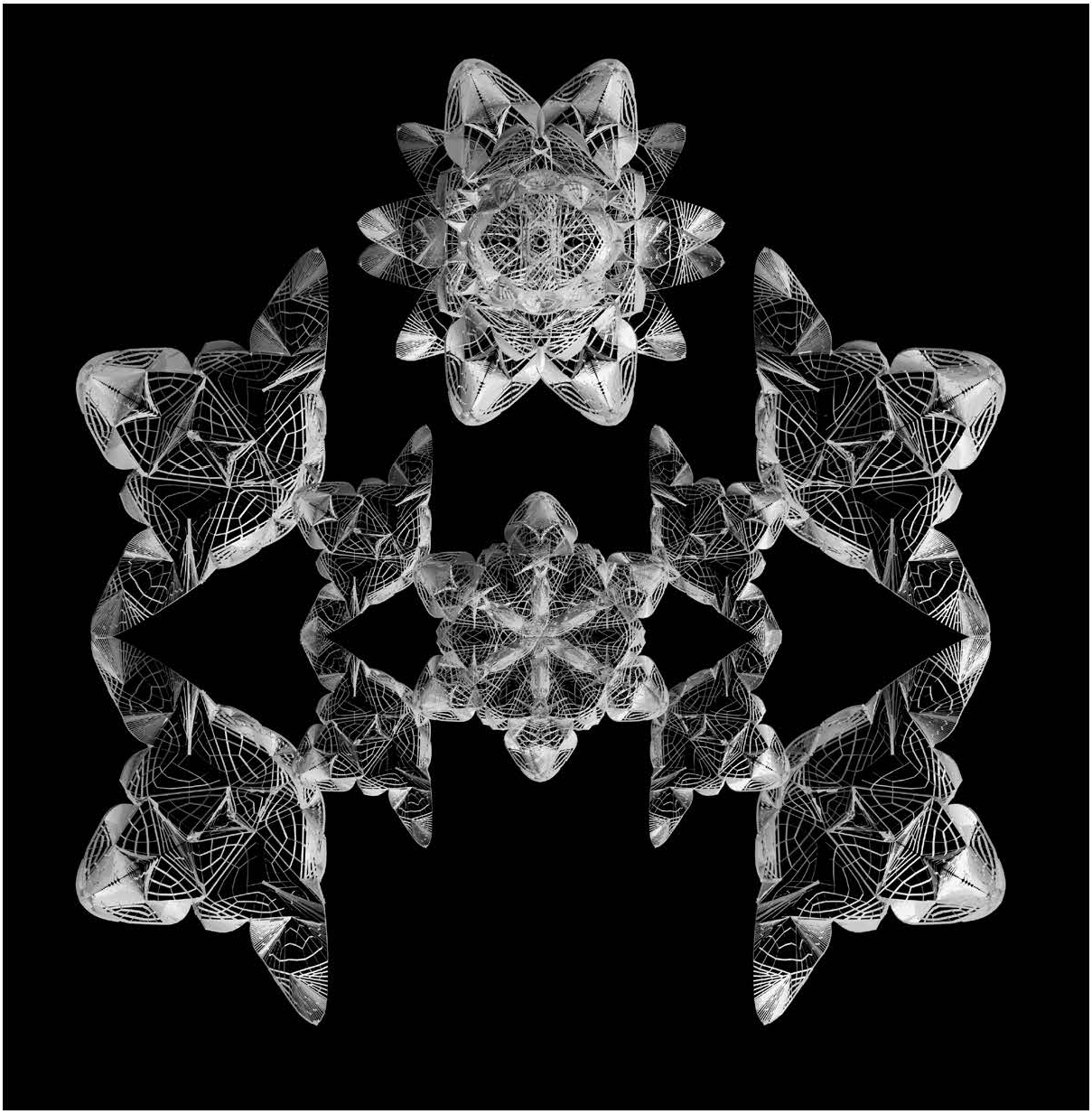
The glazing of the roof of the structure makes the structure breathable. The roof is constructed of cell structures that consist of framed smart materials.

Depending on the climate or environmental factors such as temperature, humidity, sunshine… the space between these framed cells can be opened up to the outside to let the airflow be regulated.

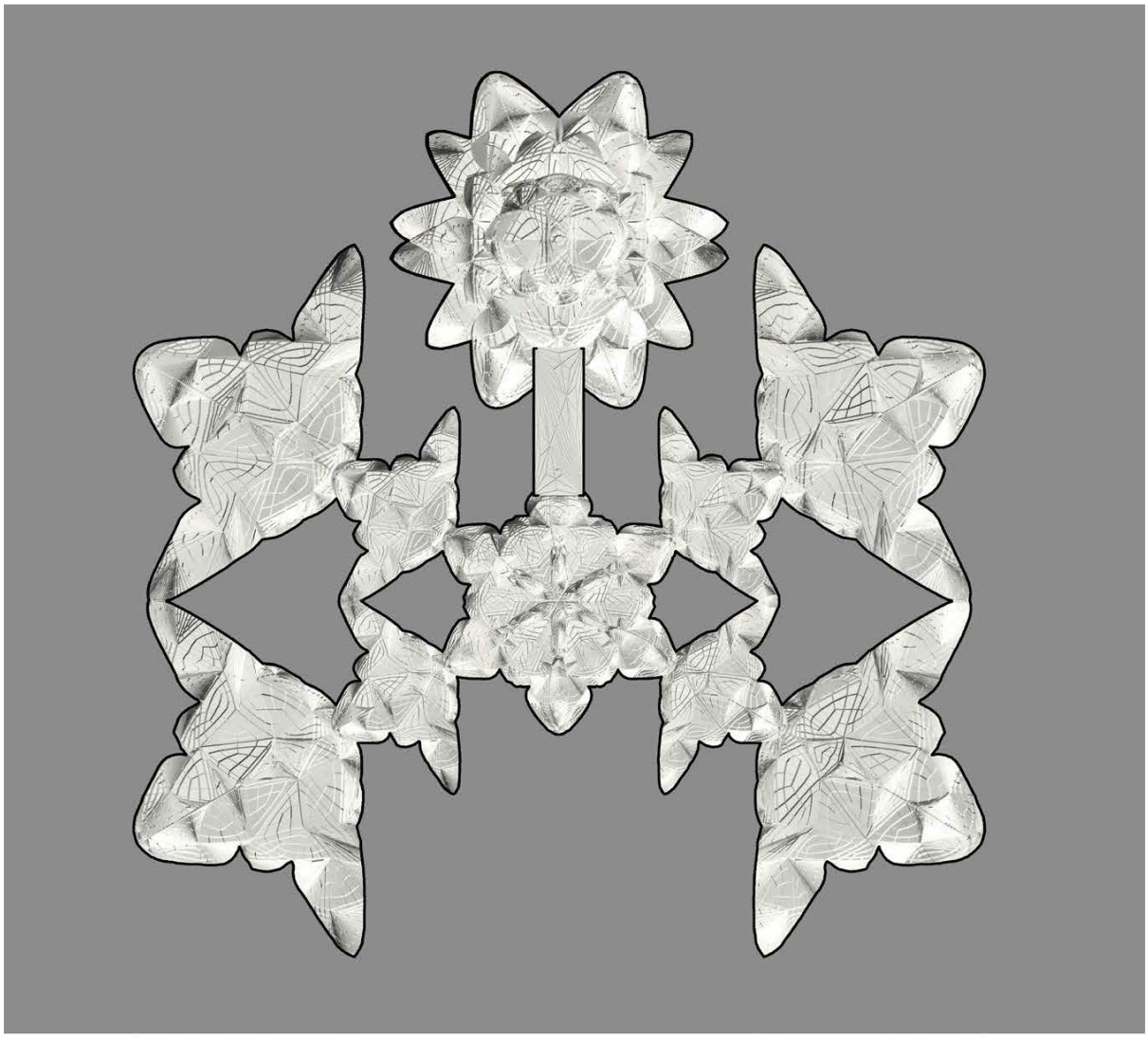
For changing the space between the framed cells in the roof of the structure shape memory alloys such as nitinol (nickel titanium) have been used. It can be deformed in one temperature and regain its original shape by change in temperature (heating).



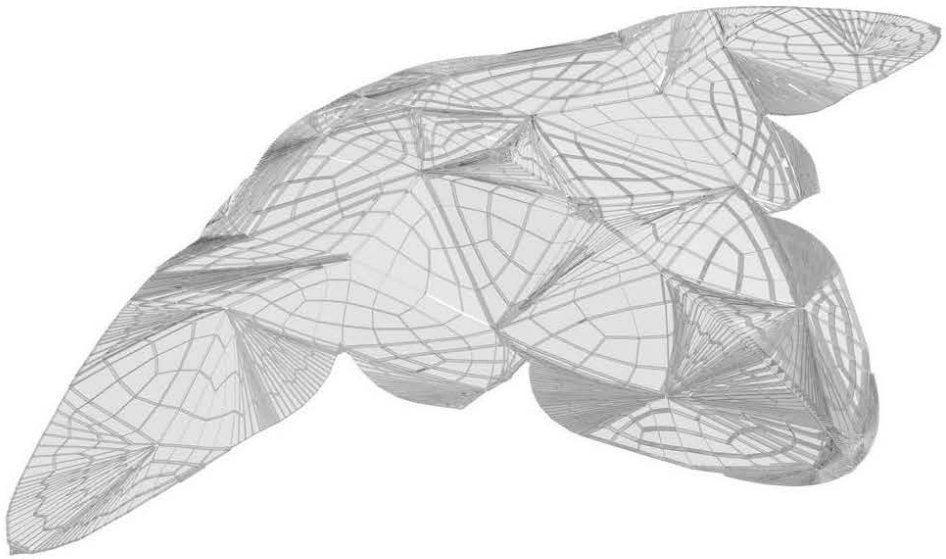
The structure of the roof

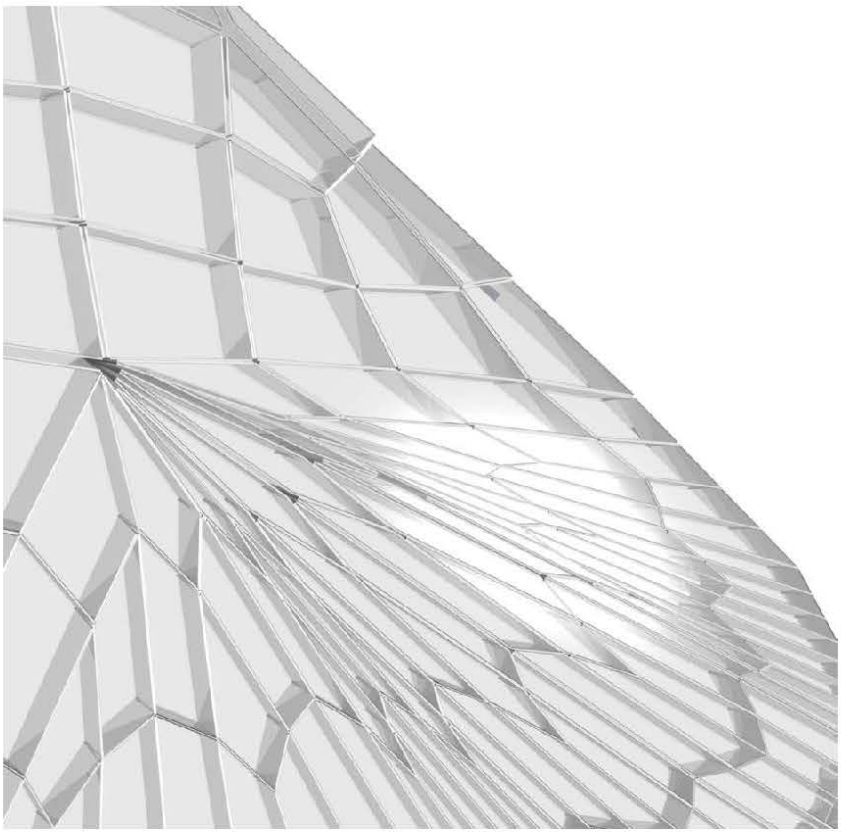


The structure of the ceiling (from inside the building)

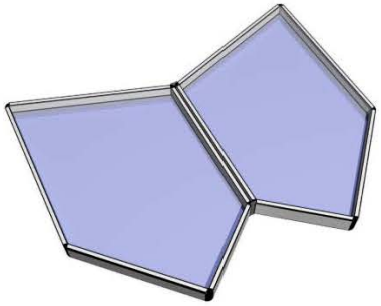


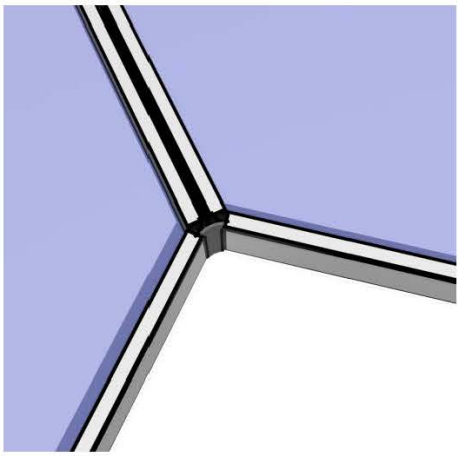
Structural plan of the building

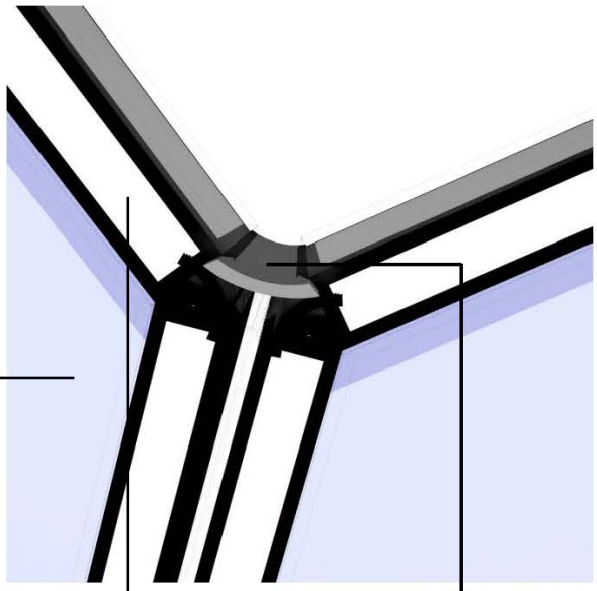




Structural detail of the roof



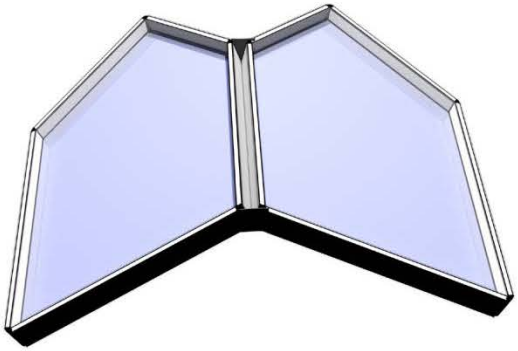




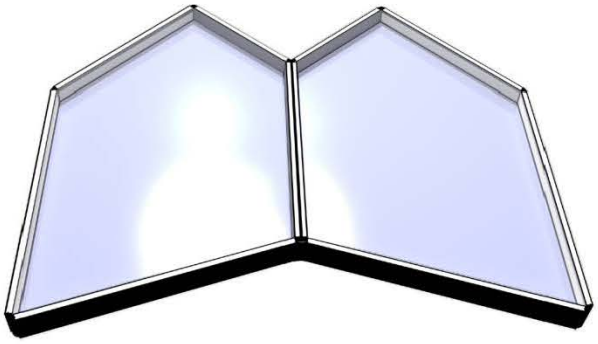
Smart material cells

The space frame cell frames

Shape memory alloys such as nitinol are used for the connection parts between the framed cells

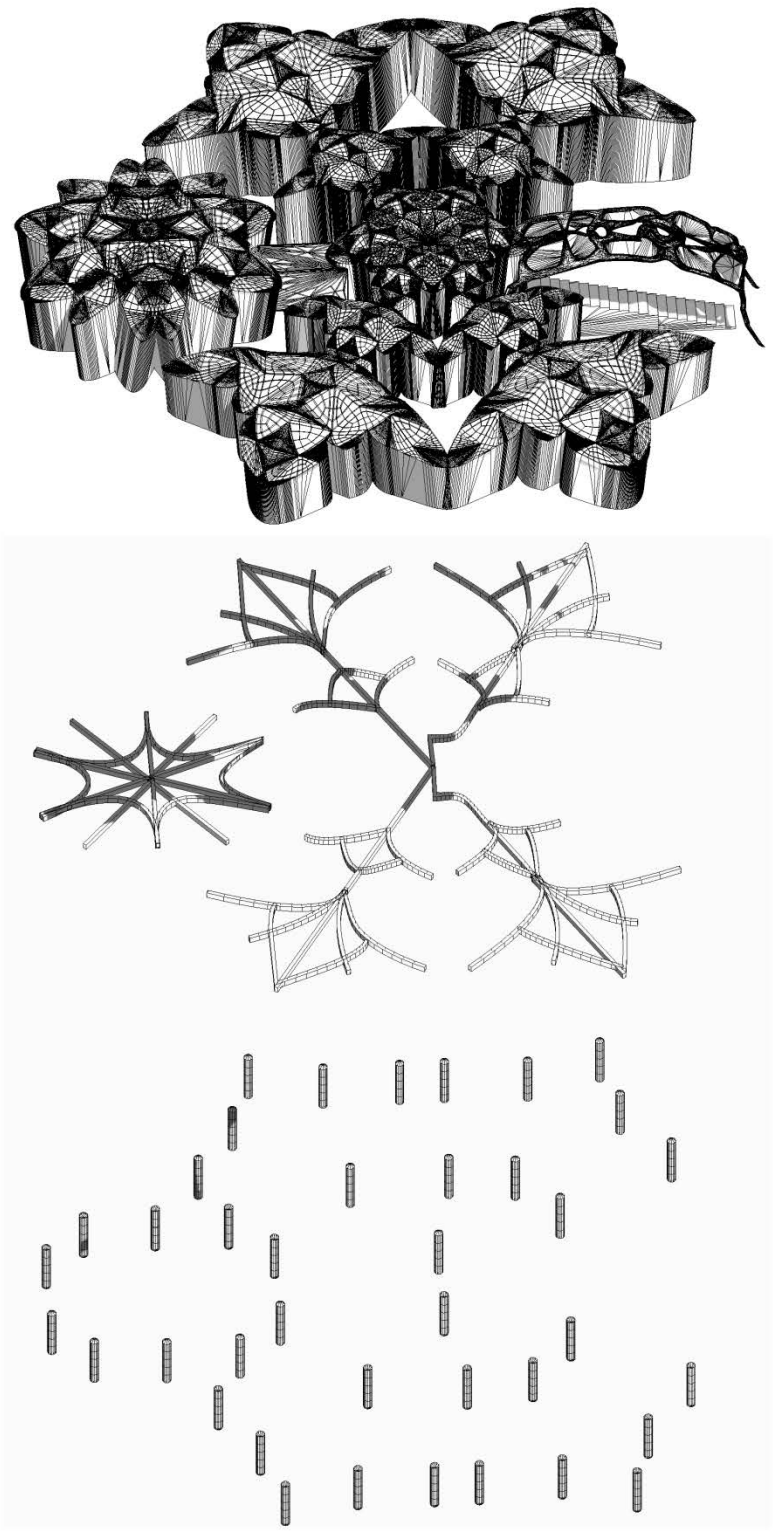


The framed cells in different climates.

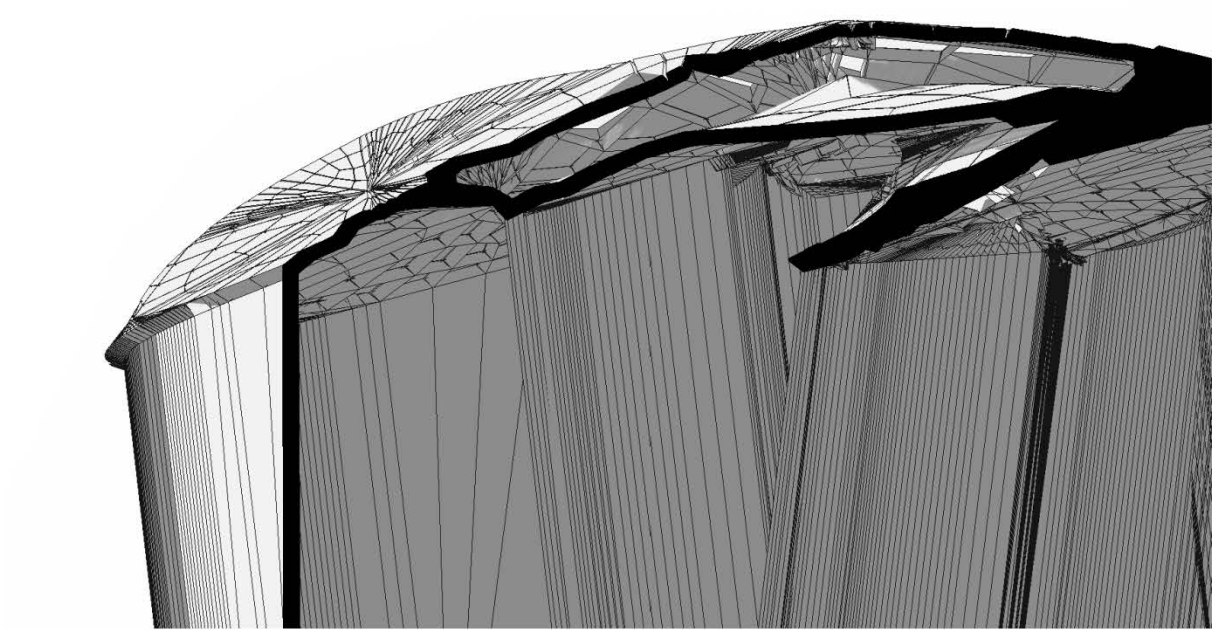


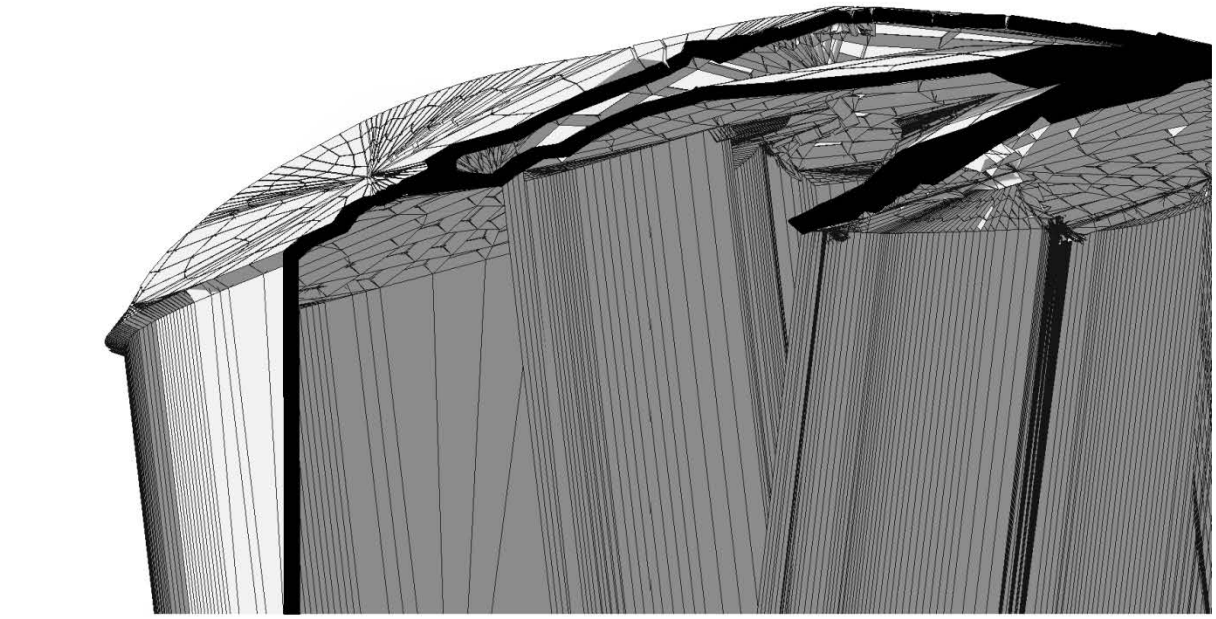
Depending on the climate or environmental factors such as temperature, humidity, sunshine… the space between these framed cells can be opened up to the outside to let the airflow be regulated. (For example in hot and humid climates the space between the cells will be opened up)

The form of the ceiling is inspired by mathematical formulas and fractal designs and also Persian tile work.



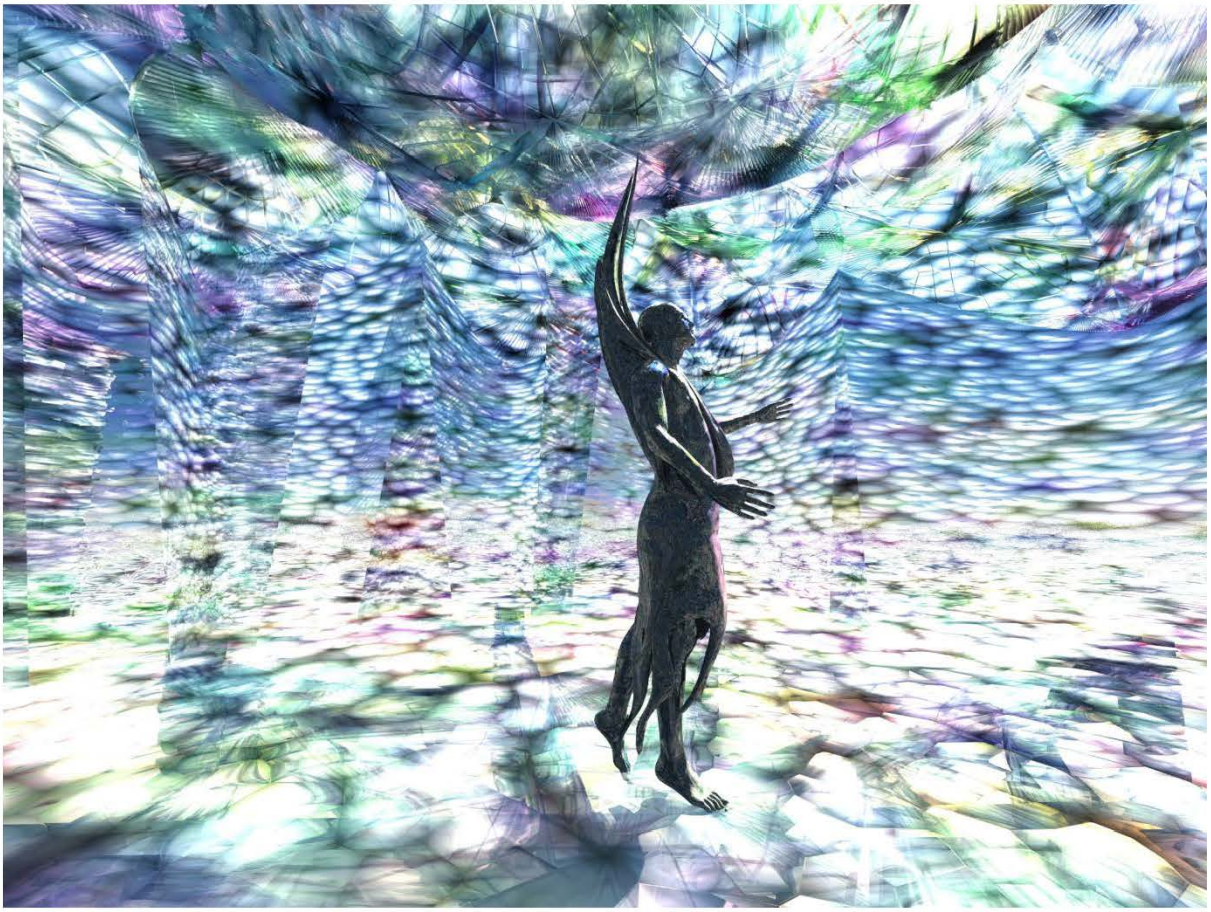
Also inspired by the anatomy of fish gills and bird wings some parts of the structure of the roof will move upward or downward for efficiency in airflow and temperature and sunlight.

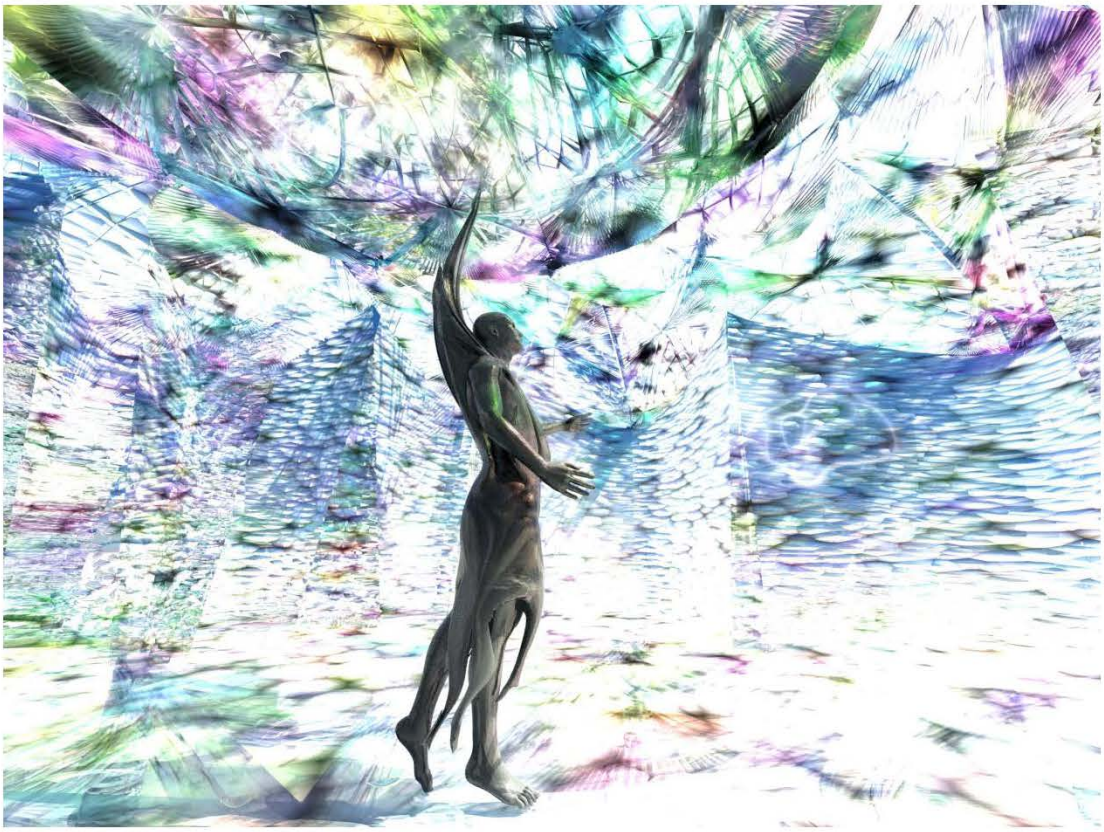


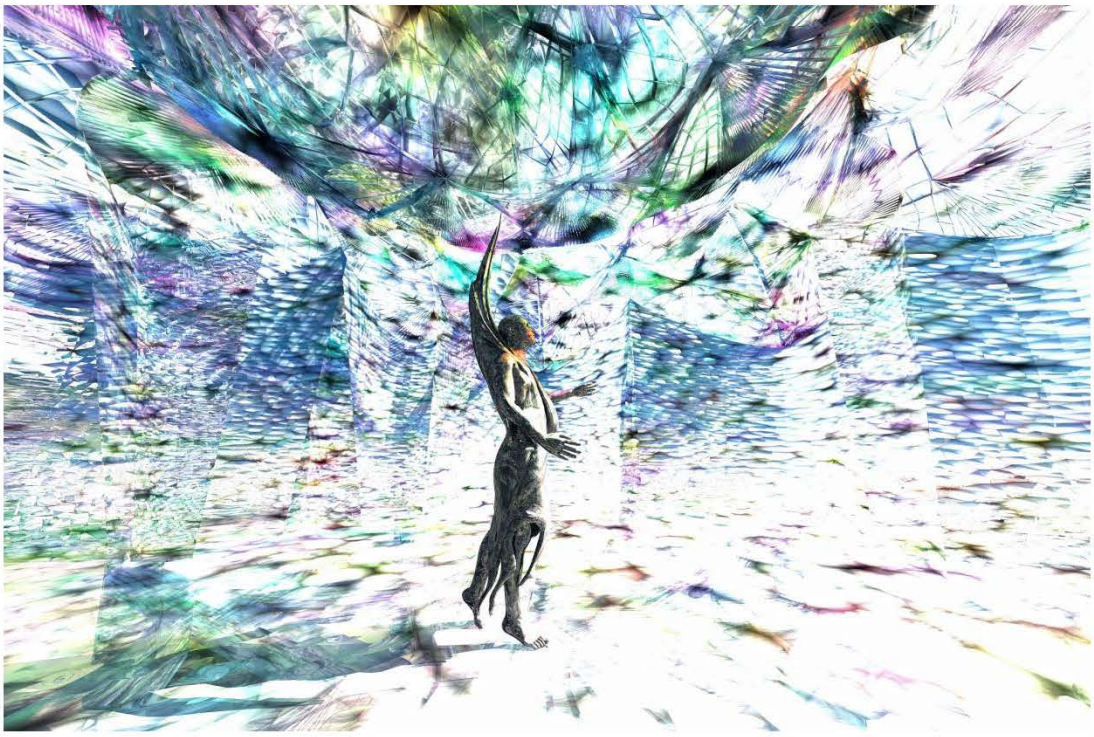


The floor and walls of the main hall are also constructed of smart materials. In the case of flooding or when water reaches the floor level of the main hall the floor will turn completely transparent to instill the feeling of being surrounded or floating in, or walking on water.

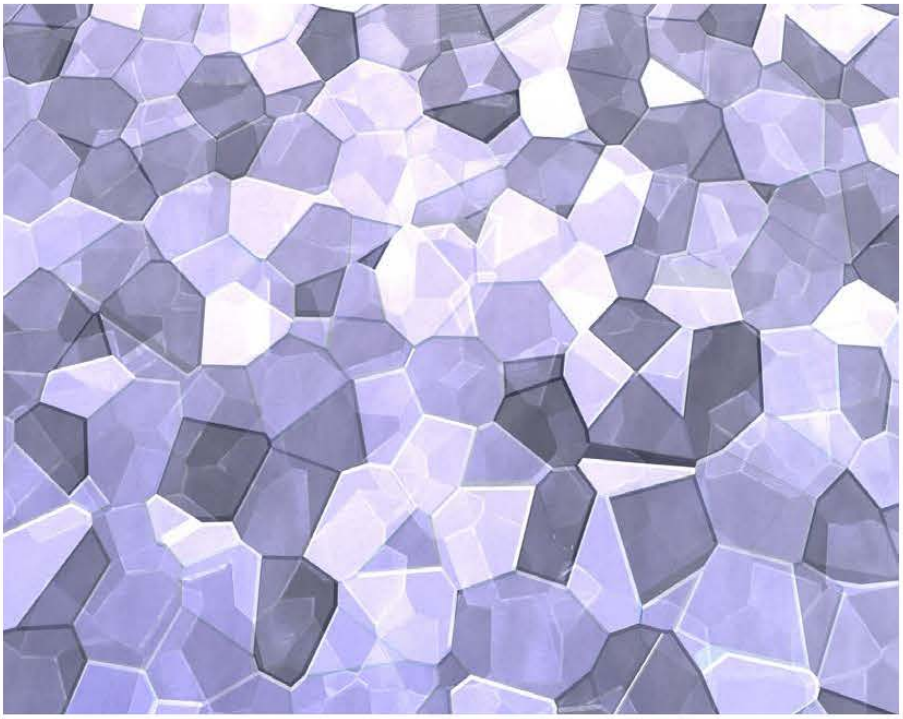
The walls and the ceiling will also change transparency during different times of the day and with the different displays of light coming through the walls and the ceiling added to the transparency changing effects of the floor the interior space will change into a kaleidoscopic ethereal space.



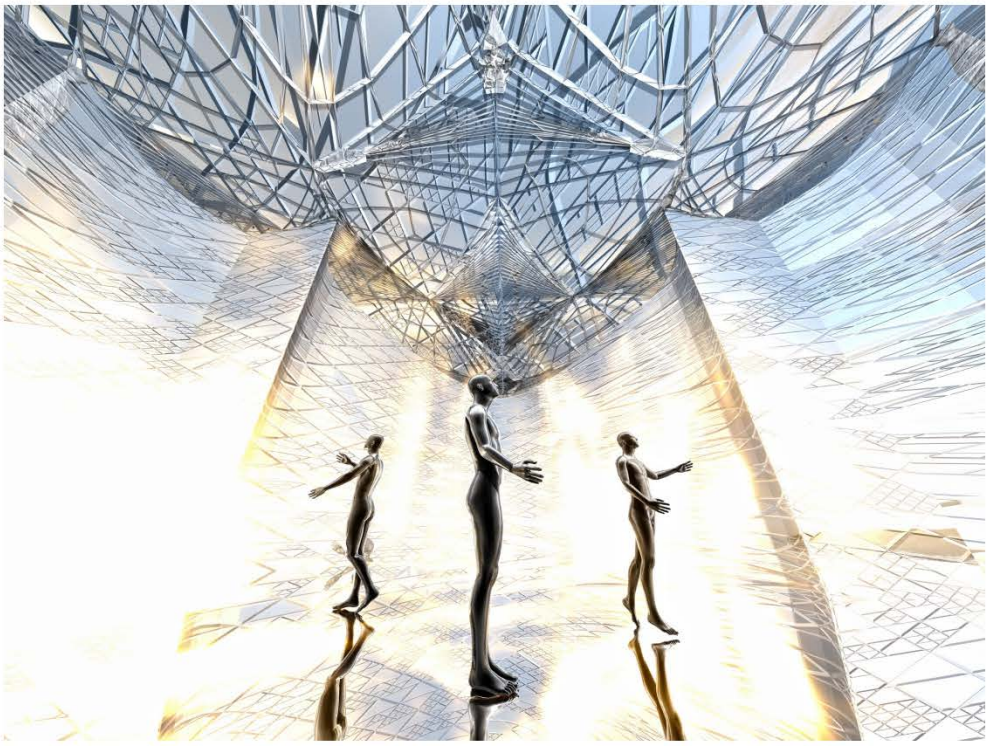




The change in transparency in the floor, the walls and the ceiling

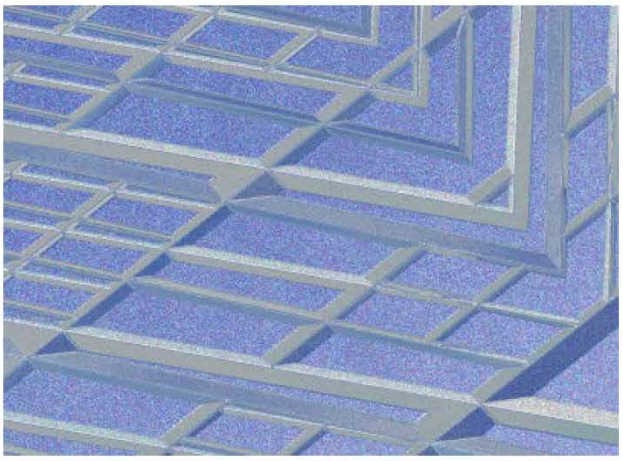


The floor of the main hall in opaque form and in transparent form



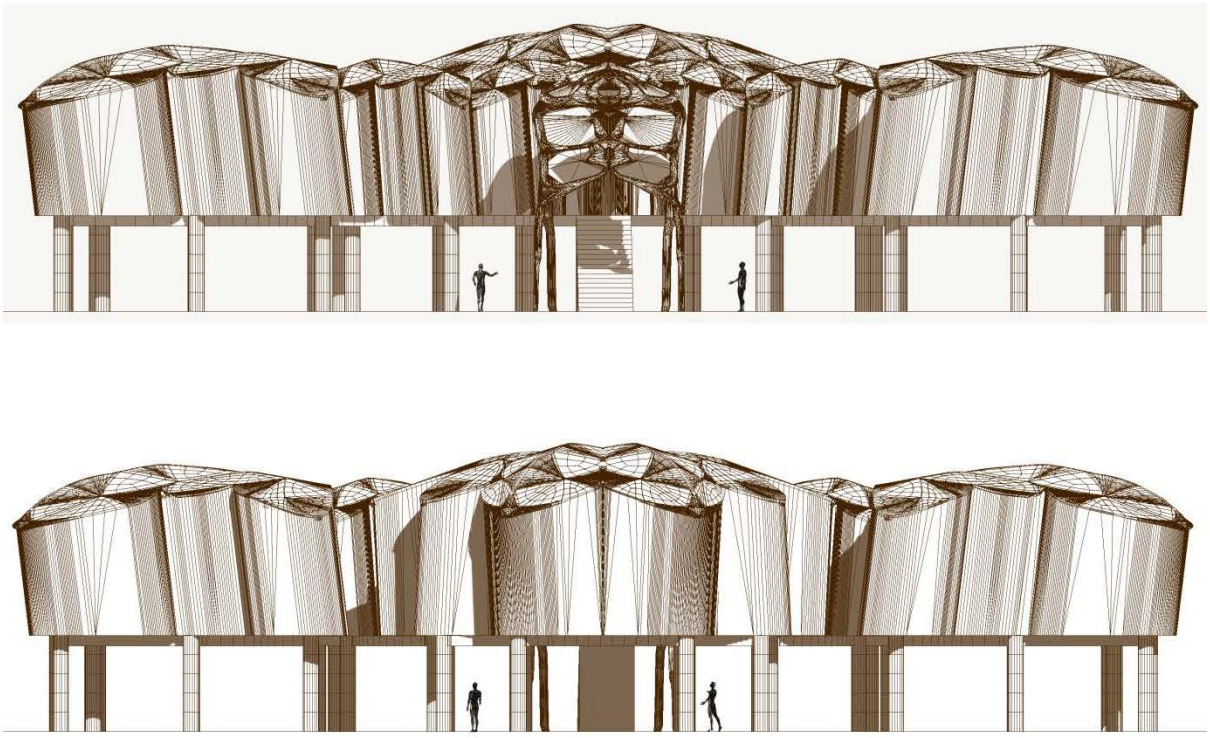
The interior space of the smaller halls of the structure.

In the smaller halls the walls and ceiling can change transparency while the floor will stay opaque and reflective.

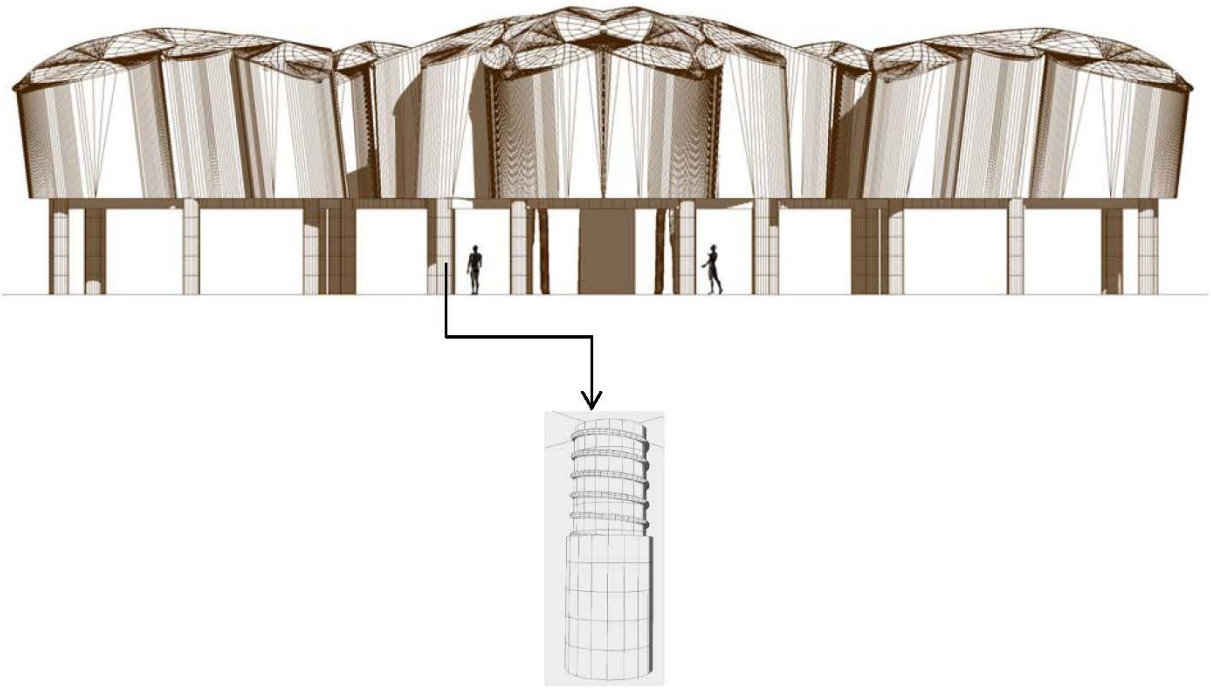


Detail of the smart materials used in the construction of the smaller spaces in the structure.

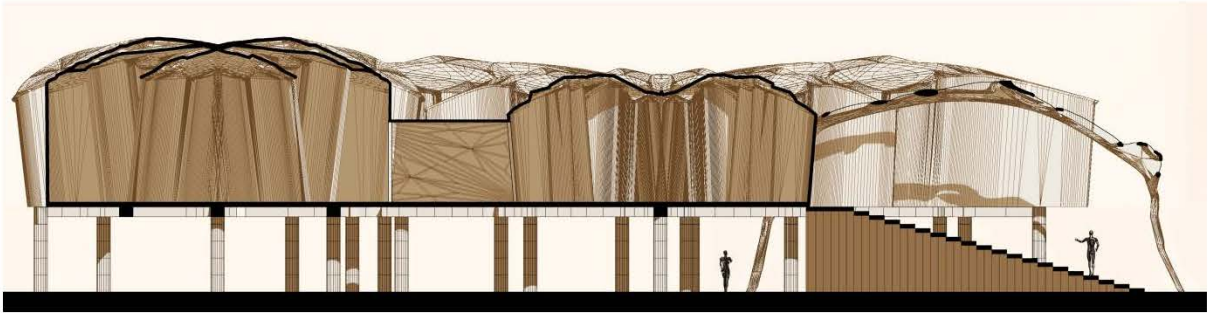
The floor consists of Aerographite (one of the lightest structural materials) and is covered with smart materials while using the same smart material in the walls and ceiling but with a transparent base.



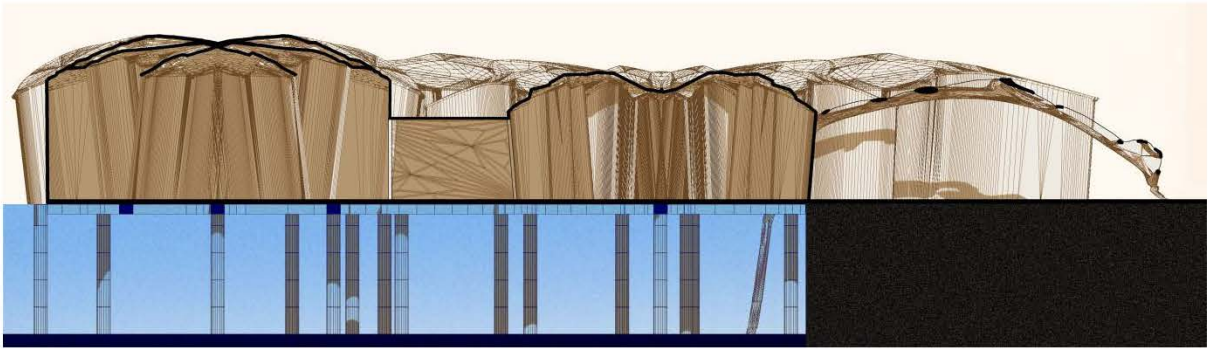
The Elevation drawings of the structure

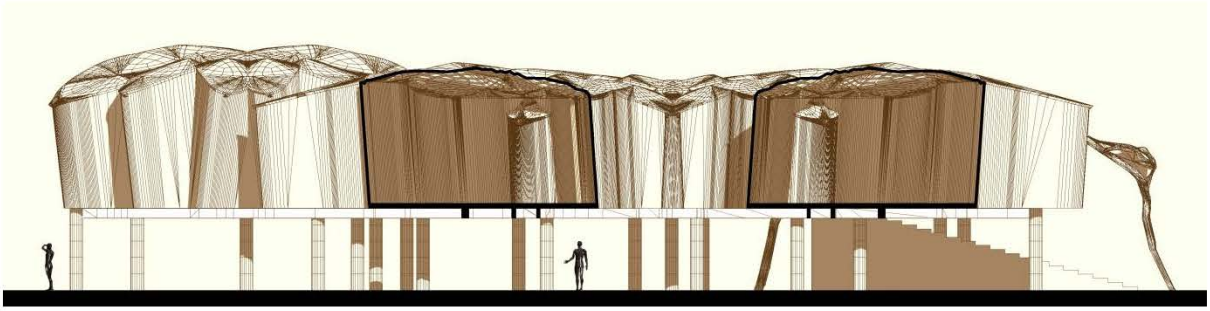


The columns which the structure is placed on are constructed of Carbotanium that is a combination of beta titanium alloy and advanced carbon composites. This material, in addition to being light is also strong that makes it an ideal material for the columns.

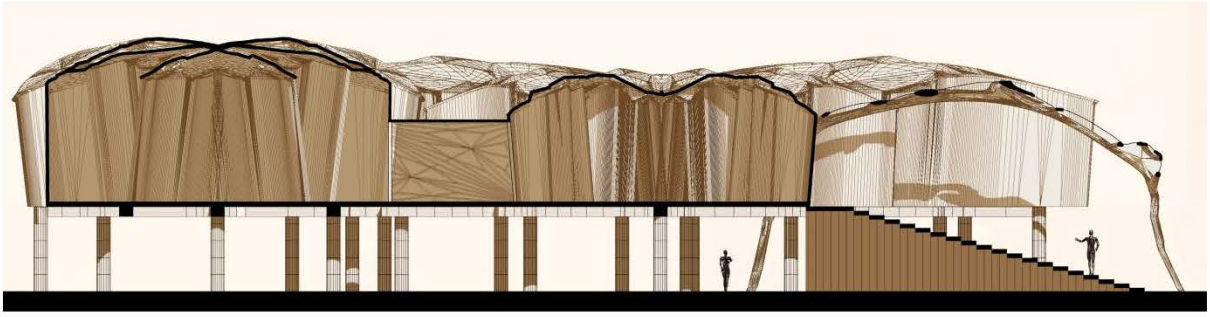


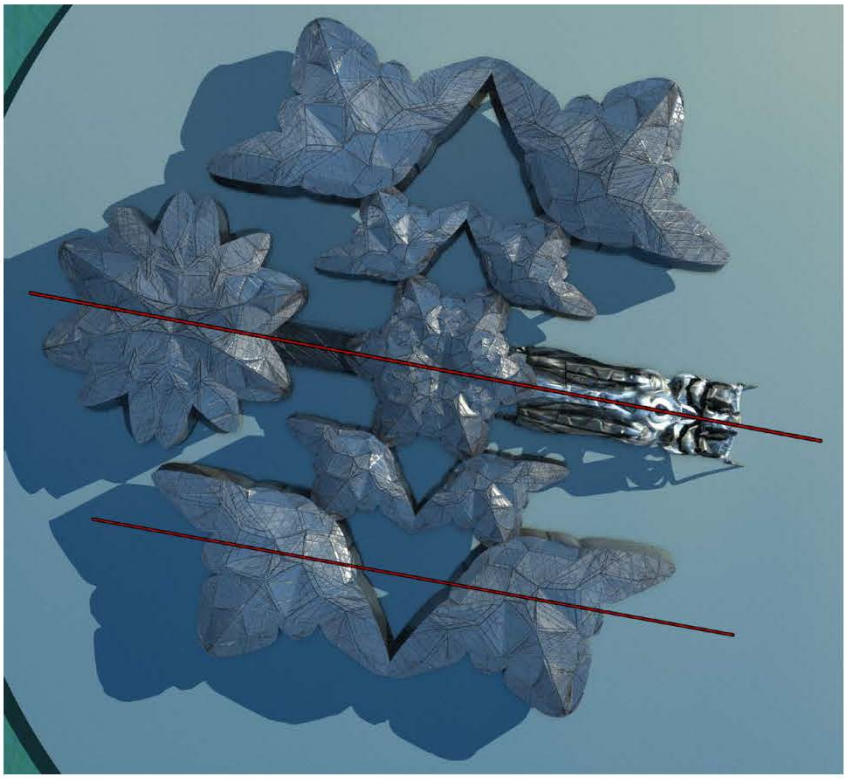
The Section drawing of the structure on land and on the water surface



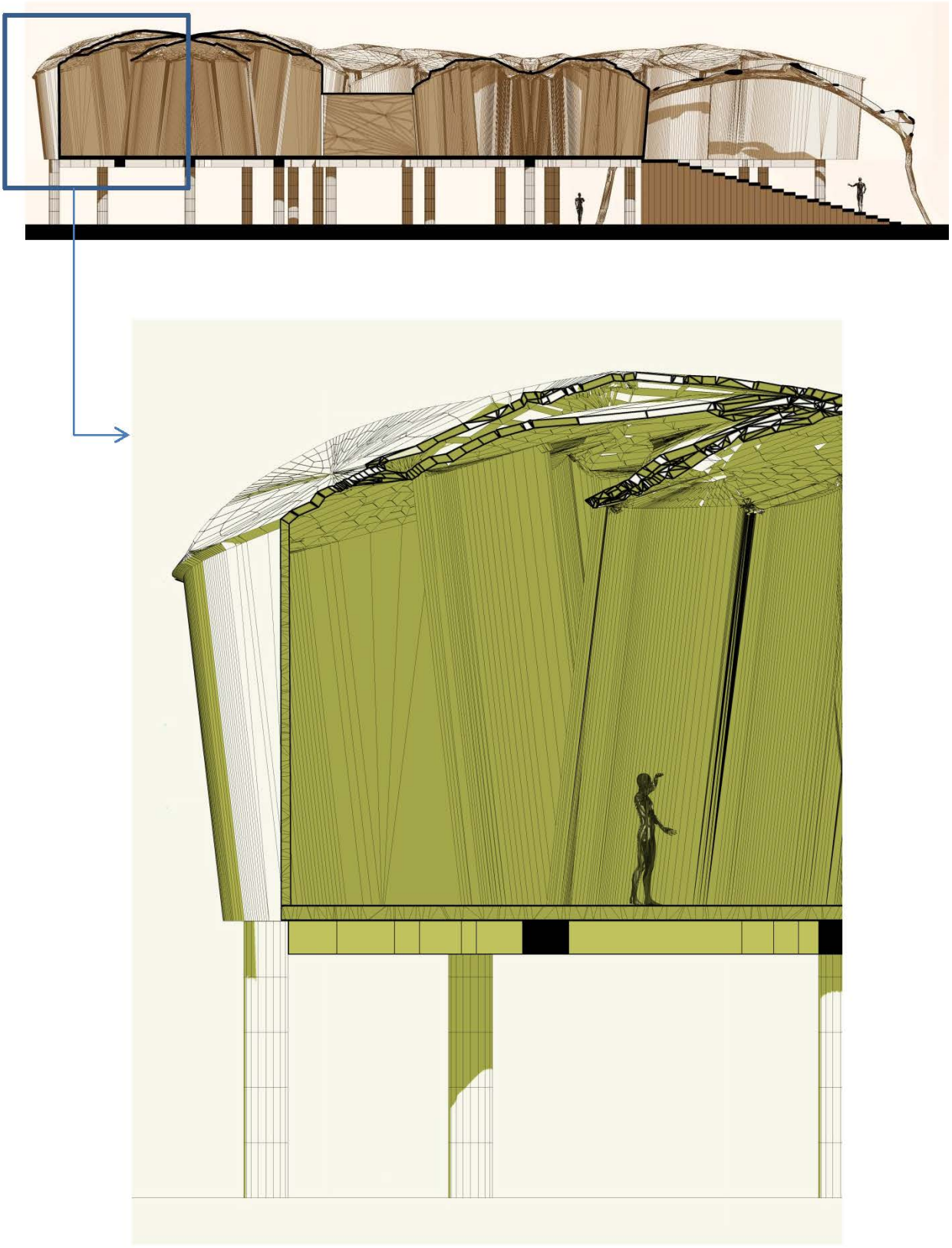


The sections of the structure

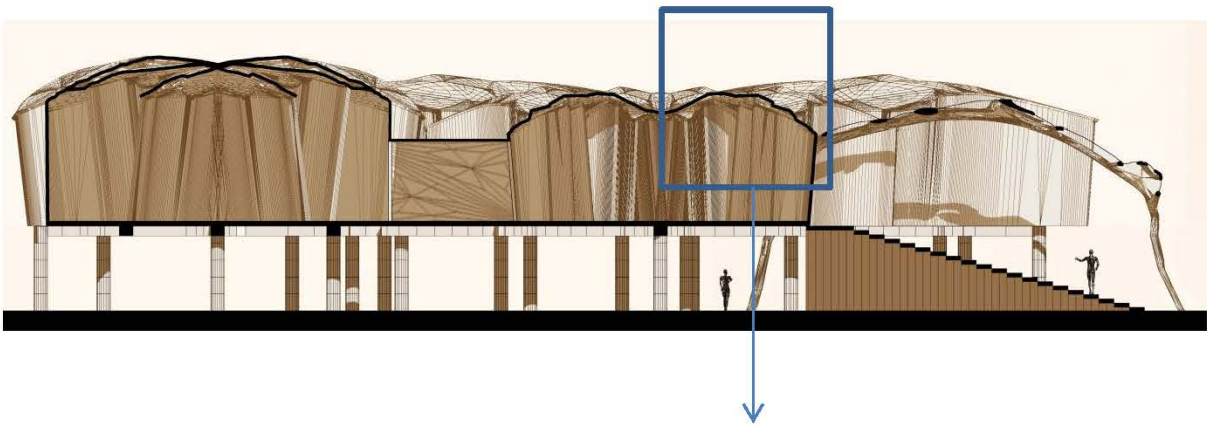




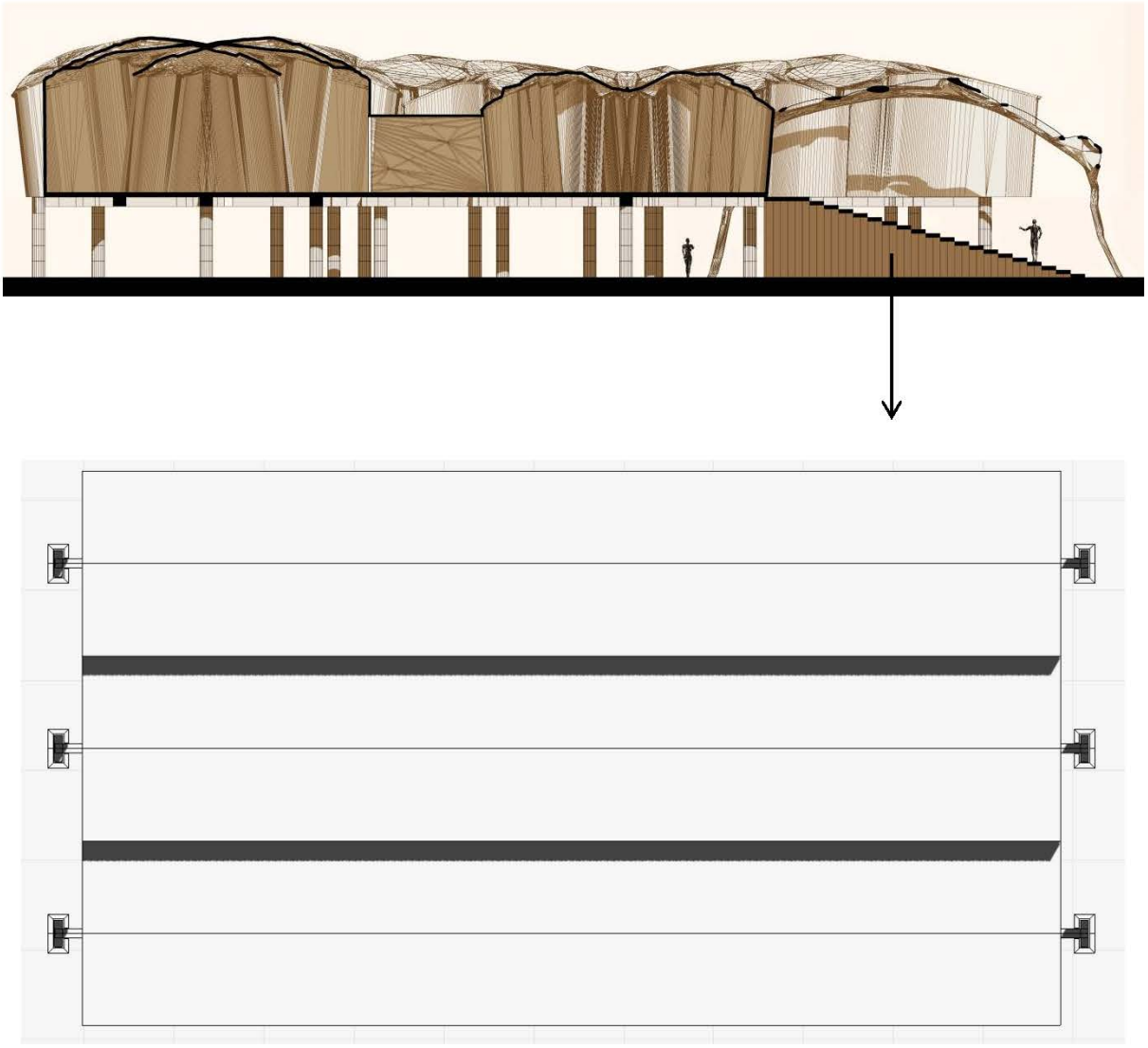
The section lines through the structure



The detailed sections of the structure

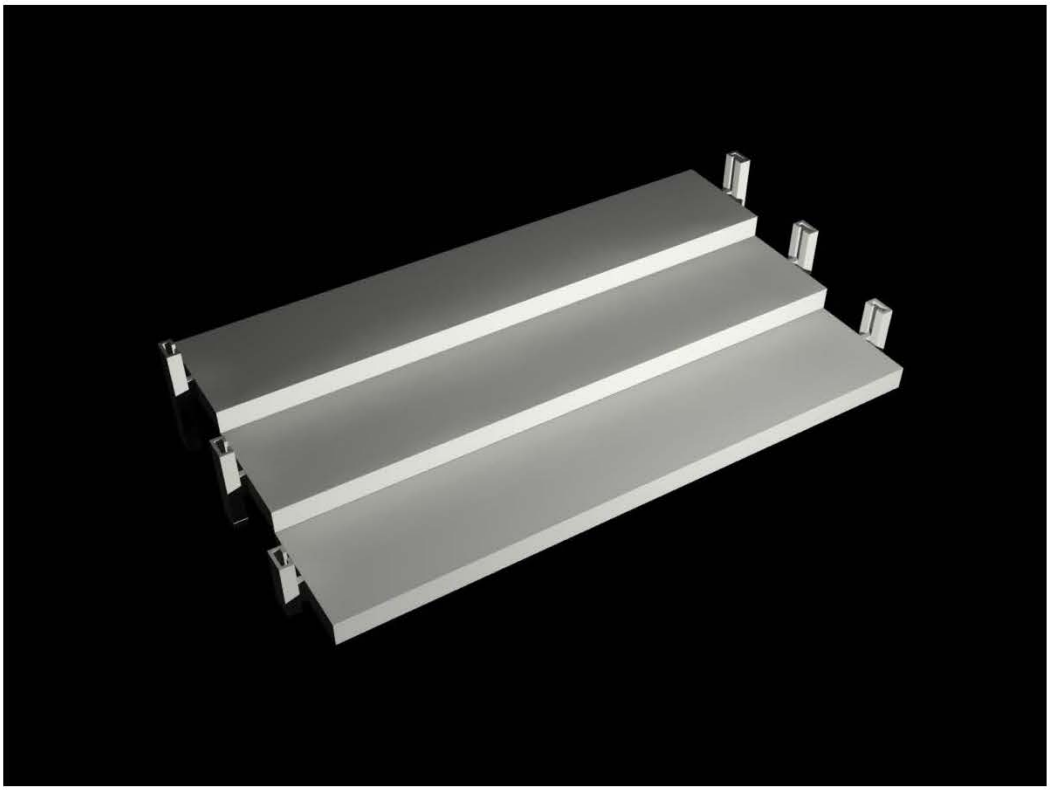


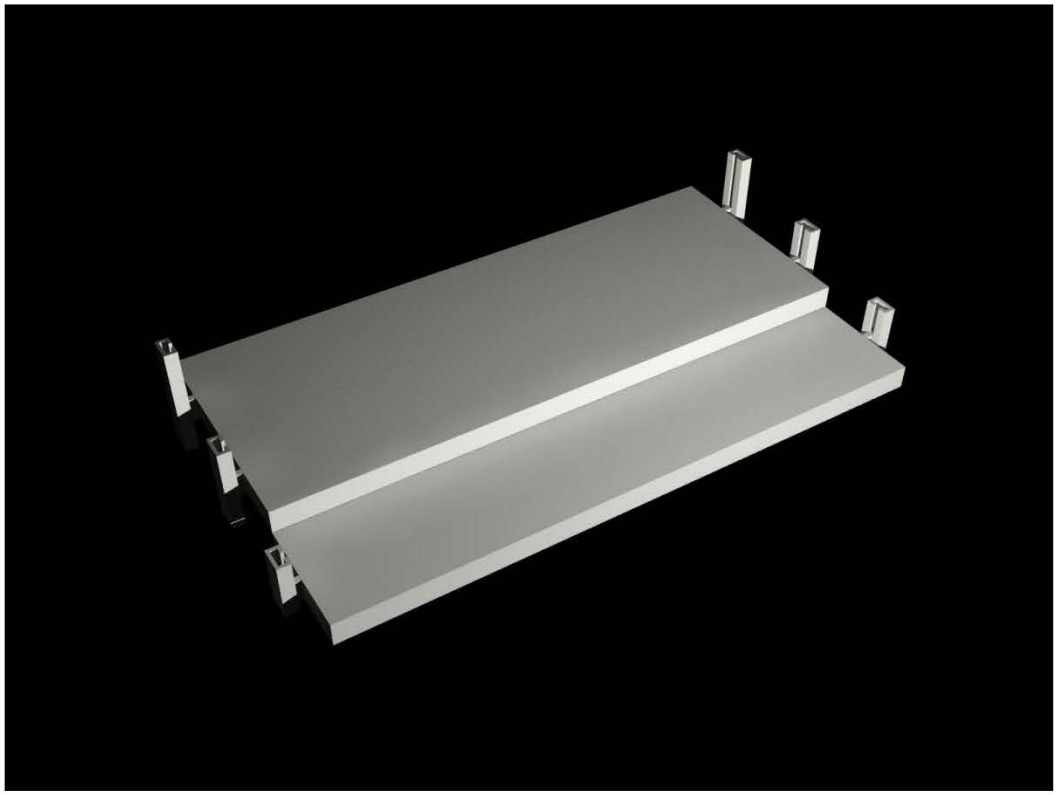
The detailed sections of the structure



The plan of the structure of the stairs

Depending on the topography and desired level for the structure, the stairs can change height by moving along the vertical rails and make different arrangements based on different topographies.



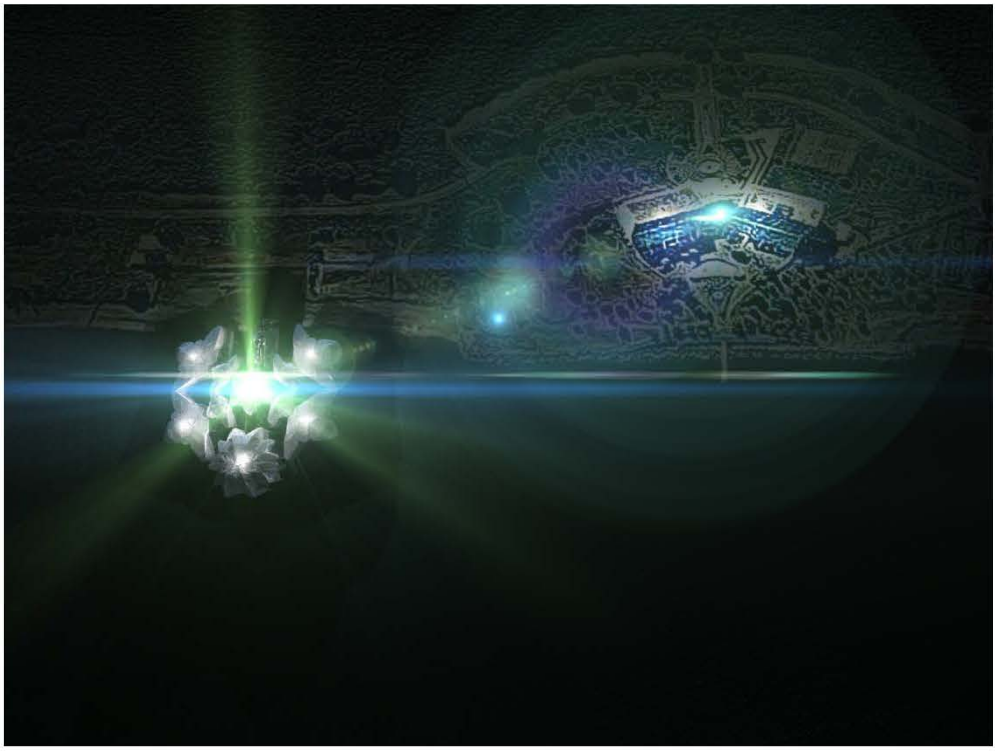


The change in height in the stairs

Bellow the designed structure is shown in different climatic conditions:

The structure located in Kish Island, south of Iran. (Hot and humid climate)

The structure located in Gothenburg, Sweden. (Cold climate)



The structure located in Namak Abrood, north of Iran. (Mild and humid climate)

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